MANITOWOC PUBLIC UTILITIES

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Mr. James G. Crawford, P.E.
Wisconsin Department of Natural Resources
Northeast Region Air Program
2984 Shawano Ave.
Green Bay, WI 54313-6727

October 31, 2011

RE: Boiler B09 Stack Test Report

Dear Mr. Crawford:

Enclosed are two copies of the stack test report required by Permit No.: 436035930-P20 conditions I.D.13.b.(1) and I.D.14.b.(3). The report details the ammonia and sulfuric acid mist Compliance Tests performed on Manitowoc Public Utilities Boiler No. 9 (B09) September 28-29, 2011 in Manitowoc, WI. Mostardi Platt performed the compliance tests and the results are documented in Report No. M113908 and summarized as follows:

Boiler	Constituent	Average Emission Rate ppm	Permit Limit ppm
B-09	Ammonia	2.64	25

Boiler	Constituent	Average Emission Rate Lb/hour	Permit Limit Lb/hour
B-09	Ammonia	1.01	15.8

Boiler	Constituent	Average Emission Rate Lb/mmBtu	Permit Limit Lb/mmBtu
B-09	Sulfuric Acid Mist	0.0020 (Heat Input)	0.0045
B-09	Sulfuric Acid Mist	0.0022 (F-factor)	0.0045

B09 Compliance Status:

- Ammonia test results were in compliance with the applicable permit limitations of Permit 436035930-P20 conditions I.D.13.a. (1) (a) and I.D.13.a. (1) (b).
- Sulfuric acid mist test results were in compliance with the applicable permit limitation of Permit 436035930-P20 conditions I.D.14.a.(1).

If you have any questions regarding the stack test report, or require additional information, please contact me.

Sincerely,

Thomas E. Reed, P.E.
Environmental Engineer
Manitowoc Public Utilities
Phone: 920-686-4384
Cell: 920-973-7134
Fax: 920-686-4348

Cc:
Red Jones – MPU
Jerry Ahlswede – MPU
Mark Boeckman – MPU
Tim Harding – MPU
Steve Bacalzo – MPU

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Emission Compliance Test Report

Manitowoc Public Utilities
Manitowoc Generating Station
Boiler B09 Outlet Duct
Manitowoc, Wisconsin
September 28 and 29, 2011

Operating Permit Facility ID: 436035930

Operating Permit #: 436035930-P20

Report Submittal Date
October 27, 2011

Prepared By

Mostardi Platt

Report No. M113908

888 Industrial Drive
Elmhurst, Illinois 60126
630-993-2100

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1.0 Introduction

MOSTARDI PLATT conducted an emissions compliance test program for Manitowoc Public Utilities in Manitowoc, Wisconsin on September 28 and 29, 2011 on the Boiler B09 Outlet Duct. This report summarizes the results of the test program and test methods used.

The test location, test dates, and test parameters are summarized below in Table 1.

Table 1

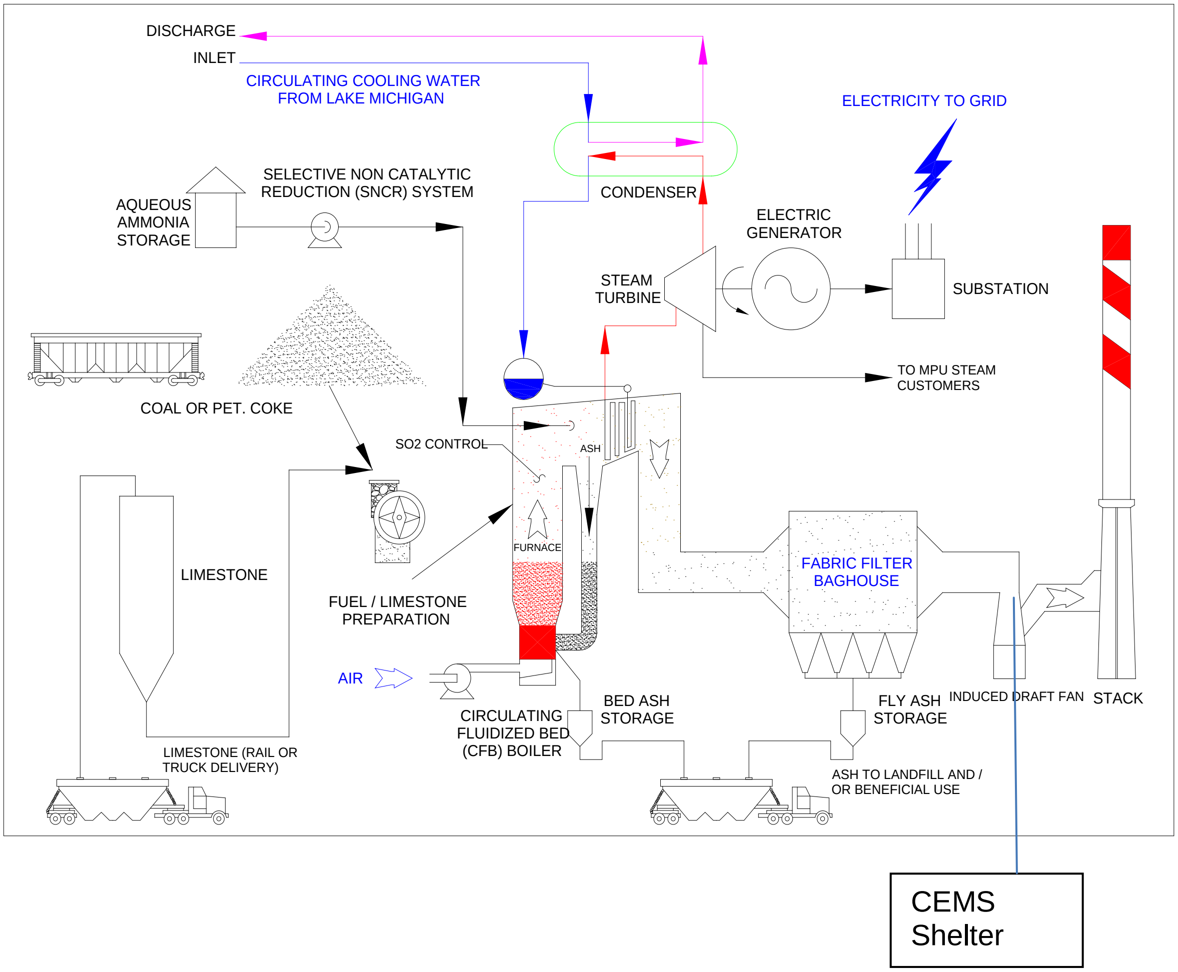
Test Overview

Test Location	Test Date	Test Parameters
Boiler B09 Outlet Duct	September 28, 2011	Ammonia (NH_3)
Boiler B09 Outlet Duct	September 29, 2011	Sulfuric Acid Mist (SO_3)

B09 Process Summary

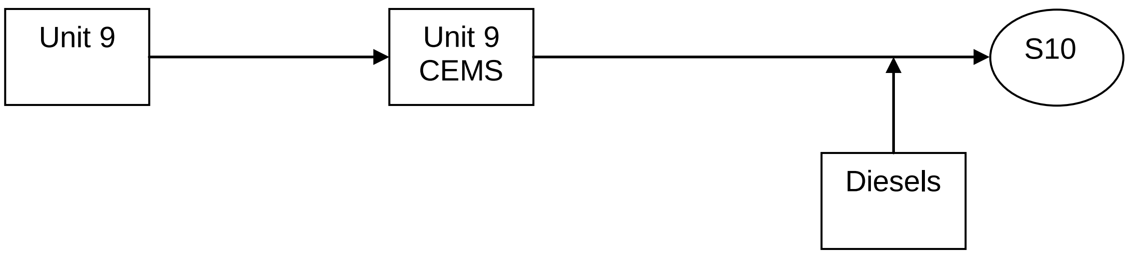
Manitowoc Public Utilities Unit #9 is an atmospheric pressure circulating fluidized bed (CFB) boiler that fires coal, petroleum coke, paper pellets or a combination of any of the three fuels, along with natural gas as a start-up fuel. The boiler produces steam, which is used to turn a steam turbine/electric generator set and to provide steam for off-site utilization (cogeneration). The Manitowoc Public Utilities Power Plant is located at 701 Columbus Street in the City of Manitowoc, in Manitowoc County, Wisconsin. The WDNR FID No.: is 436035930. The Manitowoc Public Utilities business office is located on the same site with an address of 1303 South 8th Street. The simplified process flow diagram of the CFB unit is shown in Figure 1.

FIGURE 1. Process flow diagram of the Unit 9 steam/electric cogeneration unit.



Unit 9 is connected to a single 63 MW generator. The exhaust from unit 9 is continuously monitored prior to combining with the exhaust from diesel unit 2 and discharging out Stack S10, see Figure 2. Opacity monitoring using a certified COM is performed at an elevated monitoring location on stack S10 for Unit 9 and the diesel.

FIGURE 2.



Atmospheric Pressure Circulating Fluidized Bed Boiler Description - (Boiler 09)

The Atmospheric Pressure Circulating Fluidized Bed boiler (CFB) boiler provides the steam necessary to power the steam turbine and electric generator. The CFB boiler technology is significantly different from conventional utility power boilers utilizing pulverized coal, stoker, or cyclone boiler technology, since it has the ability to significantly reduce emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_X), two pollutants of concern in acid deposition and, in the case of NO_X emissions, ground level ozone formation. The mechanism responsible for reducing SO_2 and NO_X emissions is the use of limestone as part of the fluidized bed "matrix" and the relatively low combustion temperatures, respectively. CFB boiler technology is considered a "Clean Coal Technology" by the U.S. Department of Energy and the U.S. Environmental Protection Agency.

The CFB boiler will combust coal and /or petroleum coke (and, during startup, natural gas) in a limestone matrix. In the furnace section of the CFB boiler a mixture of fuel, limestone, and ash is suspended or "fluidized" in an upwardly flowing gas stream. Although the fuel particles and limestone are solids, the combination of fuel particles, limestone and combustion air exhibit fluid-like properties. Combustion air forced in at the bottom of the furnace keeps the bed in a constantly upward moving flow. At the top of the furnace, relatively large entrained particles are separated from smaller ash particles and the combustion gases and returned to the furnace until combustion is complete. Because of the circulating nature of the fluidized bed, this combustion technology is referred to as a *circulating* fluidized-bed (CFB) boiler.

Combustion takes place within the furnace "bed" with high furnace heat transfer rates but low combustion temperatures ranging from 1,500 to 1,650°F. Because thermal NO_X formation is a high temperature process occurring at temperatures in excess of 2,000°F, the lower CFB boiler operating temperature significantly reduces NO_X production. The addition of limestone and hydrated ash to the fluidized bed allows the boiler to remove fuel sulfur directly in the boiler. The boiler is equipped with an ammonia injection SNCR system in addition to good combustion practices to control the nitrogen oxide emissions. Combustion control is better than expected and operation of the SNCR system is not necessary at all times in order to comply with the applicable nitrogen oxide emission limitations. The installation of CEMS equipment is required for demonstrating compliance with sulfur dioxide, nitrogen oxides, and opacity emission limitations. Quarterly excess emission reports are filed with the WDNR from the certified instruments demonstrating compliance with the applicable emission limitations. The CEMS is part of the B09 Part 75 system and emission reports are filed quarterly with EPA for the ARP and CAIR.

Air Pollution Control Operation Permit 436035930-P20 permit limitations for Unit 9 are summarized in the following table:

UNIT 9 Permit Limitations				
Pollutant	**Regulation**	**Standard**	**Units**	**Ave. Period**
Particulate Matter	NR 415.06(2)(c), Wis. Adm. Code	0.03	lb/mmBtu	n/a
Particulate Matter (PM10)	§ 285.65(3), Wis. Stats.	0.03	lb/mmBtu	n/a
Sulfur Dioxide	NR 440.20(4), Wis. Adm. Code § 285.65(7) and (3) Wis. Stats.	0.30 71.2	lb/mmBtu tons per month	30 days 12 months
Nitrogen Oxides	NR 440.20, Wis. Adm. Code § 285.65(7) and (3) Wis. Stats.	0.155 24.62	lb/mmBtu tons per month	30 days 12 month
Carbon Monoxide	NR 405.08(20)	0.15	lb/mmBtu	24 hours
Volatile Organic Compounds	NR 419.03, Wis Adm. Code	0.013	lb/mmBtu	n/a
Lead	§ 285.65(7) Wis. Stats.	2.0×10^{-4}	lb/mmBtu	n/a
Mercury	§ 285.65(7) Wis. Stats.	3.52×10^{-5}	lb/mmBtu	n/a
Fluoride	§ 285.65(7) Wis. Stats.	0.0017	lb/mmBtu	n/a
Visible Emissions	NR 431.05, Wis. Adm. Code	20%		6 min ave.
Benzene	§ 285.65(7) Wis. Stats.	0.0325	Lb/hour	n/a
Polychlorinated Dibenzo-p-Dioxins	NR 445.04(3)(b), Wis Adm. Code	BACT		n/a
Ammonia	NR 445.04(1), Wis Adm. Code	25	ppm	n/a
	NR 445.04(1), Wis Adm. Code	15.8	Lb/hour	n/a
Sulfuric Acid Mist	§ 285.65(7) Wis. Stats.	0.0045	lb/mmBtu	24 hours
Formaldehyde	§ 285.65(3) Wis. Stats.	0.0060	Lb/hr	n/a

The identification of individuals associated with the test program is summarized below in Table 2.

Table 2

Test Personnel

Location	**Address**	**Contact**
Test Facility	Manitowoc Public Utilities MPU Power Plant 701 Columbus Street Manitowoc, Wisconsin	Mr. Thomas E. Reed (920) 686-4384 (phone) tomreed@mpu.org mailto: chris.mahin@knaufusa.com
Testing Company Representative	Mostardi Platt 888 Industrial Drive Elmhurst, Illinois 60126	Mr. A. Lawrence Sorce (630) 993-2100 (phone) lsorce@mp-mail.com

The test crew consisted of Messrs. R. Sollars and A. L. Sorce of Mostardi Platt. The purpose of the test program was to determine the emission rates of NH_3 and SO_3 at the Boiler B09 Outlet Duct.

2.0 Executive Summary

Selected results of the test program are summarized below, in Table 3. A complete summary of emission test results follows the narrative portion of this report.

Table 3

Test Results

Test Location	Date	Test Parameter	Emission Rate	Emission Limit
Boiler B09 Outlet Duct	9/28/11	NH_3	2.64 ppm	25 ppm
	9/28/11	NH_3	1.01 lbs/hr	15.8 lbs/hr
	9/29/11	SO_3	0.0020 Lbs/MMBtu (Heat Input)	0.0045 Lbs/MMBtu (Heat Input)
	9/29/11	SO_3	0.0022 Lbs/MMBtu (F-factor)	0.0045 Lbs/MMBtu (F-factor)
	9/29/11	SO_3	1.41 Lbs/hr	N/A
	9/29/11	SO_3	0.06 Lbs/ton of fuel input	N/A

A cyclonic flow test indicating that the unit meets the less than 20 degree angle requirement was conducted on September 27, 2011 and is included in the Appendix. The average angle was 8.88 degrees.

3.0 Test Methodology

Emissions testing was conducted following the methods specified in 40 CFR, Part 60, Appendix A. Schematics of the sampling trains used are included in the Appendix. Copies of field data sheets and/or analyzer print-outs for each test run are included in the Appendix.

The following methodologies were used during the test program:

Method 1 Traverse Point Determination

Test measurement points were selected in accordance with Method 1. The characteristics of the measurement location is summarized below, in Table 3.

Table 3

Sample Point Selection

Location	Upstream Diameters	Downstream Diameters	Test Parameter	Number of Sampling Points
Boiler B09 Outlet Duct	> 0.5	> 2.0	NH_3	24
	> 0.5	> 2.0	SO_3	1
	> 0.5	> 2.0	Volumetric Flow	24

Method 2 Volumetric Flowrate Determination

Gas velocity was measured following Method 2, for purposes of calculating stack gas volumetric flow rate. An S-type pitot tube, differential pressure gauge, thermocouple and temperature readout were used to determine gas velocity at each sample point. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data is presented in the Appendix.

Method 3A Oxygen (O_2)/Carbon Dioxide (CO_2) Determination

Stack gas molecular weight was determined in accordance with Method 3A. A Servomex analyzer was used to determine stack gas oxygen and carbon dioxide content and, by difference, nitrogen content. All of the equipment used was calibrated in accordance with the specifications of the Method.

Conditional Test Method 027 (CTM-027) Ammonia (NH_3) Determination

Ammonia concentrations were determined using CTM-027 at the test location. An integrated 24-point sample was extracted from the gas stream and passed through dilute (0.1 N) sulfuric acid. In the dilute acid, ammonia dissolves and forms ammonia ions. The ammonia ions were then analyzed by ion chromatography. The sample train consisted of a glass-lined probe followed by a heated filter, and four impingers. The first and second impingers contained the dilute sulfuric acid, the third impinger was empty, and the fourth impinger contained silica gel to absorb any remaining moisture. The train was leak checked prior to and after each run. The samples were recovered by quantitatively transferring the contents of the first three impingers and deionized water rinses to a glass sample jar. The samples were mixed and labeled, and the level marked for transfer to the laboratory. The samples were analyzed by TEI Analytical, Inc. of Niles, Illinois.

Sulfuric Acid Mist (SO_3 as H_2SO_4) Determination

Stack gas sulfuric acid mist (H_2SO_4 and SO_3) concentrations and emission rates were determined in accordance with Consol Method 8A (Controlled Condensate Method). An ESC sampling train was used to sample stack gas, in the manner specified in the Method. Analyses of the samples collected were conducted by Mostardi Platt. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data is presented in the Appendix.

Quality assurance and quality control was demonstrated by spiking run 1 with a known amount of H_2SO_4 and verifying the recovery by re-titrating the sample. The recovery was found to be 93.75%.

4.0 Test Result Summary

Client: Manitowoc Public Utilities
Facility: Manitowoc Generating Station
Test Location: Boiler B09 Outlet Duct
Test Method: CTM-027

Source Condition	60.2 MW	59.2 MW	60.0 MW	
Date	9/28/11	9/28/11	9/28/11	
Start Time	11:30	13:45	15:30	
End Time	12:40	15:00	16:35	
	Run 1	Run 2	Run 3	Average
Stack Conditions				
Average Gas Temperature, °F	341.3	341.3	342.3	341.6
Flue Gas Moisture, percent by volume	6.6%	7.0%	6.9%	6.8%
Average Flue Pressure, in. Hg	29.10	29.10	29.10	29.10
Gas Sample Volume, dscf	64.674	66.742	65.382	65.599
Average Gas Velocity, ft/sec	60.198	60.004	59.723	59.975
Gas Volumetric Flow Rate, acfm	229,778	229,037	227,963	228,926
Gas Volumetric Flow Rate, dscfm	137,574	136,536	135,823	136,644
Average %CO_2 by volume, dry basis	14.0	13.8	14.1	14.0
Average %O_2 by volume, dry basis	5.3	5.5	5.2	5.3
Isokinetic Variance	98.3	102.2	100.7	100.4
Ammonia (NH4) Emissions				
mg of sample collected	4.76	3.66	2.60	3.67
ppm	3.47	2.58	1.87	2.64
lb/hr	1.34	0.99	0.71	1.01

Consol Controlled Condensate Titration Results Summary
Manitowoc Public Utilities
Boiler B09 Outlet Duct
September 29, 2011

Gaseous Phase SO_3 as H_2SO_4, 80% IPA Condenser Coil													
Test No.	Time	Vt-Vtb	N	Vsoln	Va	Vm(std) ft^3	C SO_3 as H_2SO_4 (lbs/dscf)	Volumetric Flow DSCFM	ppm SO_3 as H_2SO_4	lbs/hr SO_3 as H_2SO_4	lbs/ton SO_3 as H_2SO_4	lbs/mmBtu SO_3 as H_2SO_4 (F-factor Basis)	lbs/mmBtu SO_3 as H_2SO_4 (Heat Input Basis)
1	08:40 - 09:40	0.30	0.0107	100	25	7.067	1.96E-07	129,064	0.77	1.52	0.06	0.0023	0.0022
2	10:40 - 11:40	0.25	0.0107	100	25	5.918	1.95E-07	129,332	0.77	1.52	0.06	0.0023	0.0021
3	12:25 - 13:25	0.20	0.0107	100	25	5.958	1.55E-07	129,482	0.61	1.21	0.05	0.0018	0.0017
							Average	**129,293**	**0.72**	**1.41**	**0.06**	**0.0022**	**0.0020**

QA/QC Recovery

1 ml 0.01 N H2SO4 added to Test 1.

Titrated with 0.0102 Barium Chloride
1.2 ml titrated for QA/QC Recovery

(1 ml x 0.01 N)/ 0/0102 N equals 0.98 mls.
0.98 mls plus 0.3 mls sampled Test 1 equals 1.28 mls.

1.2 mls divided by 1.28 mls times 100 equals 93.75% Recovery

5.0 Process Data

Production data and fuel use data was recorded by plant personnel during each test run in order to correlate emission rates to production and fuel use. Production data and fuel use data is found in the Appendix.

6.0 Conclusion and Certification

MOSTARDI PLATT is pleased to have been of service to Manitowoc Public Utilities. If you have any questions regarding this test report, please do not hesitate to contact us at 630-521-9400.

CERTIFICATION

As project manager, I hereby certify that this test report represents a true and accurate summary of emissions test results and the methodologies employed to obtain those results, and the test program was performed in accordance with the methods specified in this test report.

MOSTARDI PLATT

A. Lawrence Sorce

A.L. Sorce Project Manager

Jeffrey M. Crivlare

Quality Assurance
Jeffrey M. Crivlare

APPENDIX

Boiler Stack Test Operating Data

Date:September 28, 2011	Boiler: B-09	Recorded by: Thomas E. Reed
Test: Ammonia	Run: No. 1	Testing by: Platt Environmental Services, Inc.
Methods: USEPA Methods 1, 2, and 3A, 40CFR60, Appendix A and CTM-027		

Parameter	Start	Mid	Stop	Avg.	Net
Time	12:34		13:43		**1:09**
Coal Scale (A.)	318501		337068		**18,567**
Coal Scale (B.)	3890215		3908615		**18,400**
Coal Scale (C.)	47788		66059		**18,271**
Total Pounds of Fuel					**55,238**
Pounds of fuel per hour					**48,033**
Limestone (Klbs/hr)	10.7	11.2	11.8	11.2	
Limestone Scale (lbs)	512298113		512311135		**13,022**
MW Totals (MWh)	5550.7		5619.9		**69.2**
Output (MWh-gross)	59.56	60.10	60.31	59.99	
Steam Flow (Klbs/hour)	464	467	467	466	
Feed Water (Klbs/hr)	452	449	456	452	
Boiler Master (psig)	1460.0	1463.8	1461.8	1461.9	
Fuel Master (Klbs/hr)	48.2	48.1	48.0	48.1	
NOx (lbs/mmBtu)	0.038	0.039	0.037	0.038	
Differential Freeboard	7.0	7.0	6.5	6.8	
Bed Temperature (F)	1636	1637	1641	1638	
Bed Depth (in.)	26	25	25	25	
PA Flow (Klbs/hr)	319	313	314	315	
SA Flow (Klbs/hr)	259.0	263.6	259.5	260.7	
Oxygen (%)	2.97	2.98	2.95	2.97	
Opacity (%)	2.64	2.46	2.78	2.63	
Carbon Monoxide (ppm)	1	4	5	3	
Bag house (Dp inches)	3.2	3.2	3.3	3.2	
Exit gas Temperature (F)	315	314	314	314	
Output (MWh-net)	54.71	55.02	55.07	54.93	
Soot Blowing	--	--	--		
Ammonia Flow (lb/hour)	82	83	81	82	
MPU Fireman	Chip Luedtke				

NOTES: B9 is found on graphic 103, turbine is on graphic 140.

B9 suppling all extraction steam, the Diesel not online.

Boiler Stack Test Operating Data

Date:September 28, 2011	Boiler: B-09	Recorded by: Thomas E. Reed
Test: Ammonia	Run: No. 2	Testing by: Platt Environmental Services, Inc.
Methods: USEPA Methods 1, 2, and 3A, 40CFR60, Appendix A and CTM-027		

Parameter	Start	Mid	Stop	Avg.	Net
Time	14:50		16:06		**1:16**
Coal Scale (A.)	54573		75049		**20,476**
Coal Scale (B.)	925968		946211		**20,243**
Coal Scale (C.)	83296		103442		**20,146**
Total Pounds of Fuel					**60,865**
Pounds of fuel per hour					**48,051**
Limestone (Klbs/hr)	12.1	11.9	12.5	12.2	
Limestone Scale (lbs)	323866		339625		**15,759**
MW Totals (MWh)	1715684		1715759		**75**
Output (MWh-gross)	59.25	59.7	59.6	59.52	
Steam Flow (Klbs/hour)	461	461	461	461	
Feed Water (Klbs/hr)	449	443	446	446	
Boiler Master (psig)	1459.8	1461.6	1461.8	1461.1	
Fuel Master (Klbs/hr)	48.0	48.1	48.0	48.0	
NOx (ppm)	26	25	28	26	
Differential Freeboard	6.5	6.5	6.5	6.5	
Bed Temperature (F)	1645	1647	1653	1648	
Bed Depth (in.)	24	24	25	24	
PA Flow (Klbs/hr)	317	315	316	316	
SA Flow (Klbs/hr)	253.5	252.8	250.5	252.3	
Oxygen (%)	3.13	3.03	3.01	3.06	
Opacity (%)	2.92	2.69	2.23	2.61	
Carbon Monoxide (ppm)	6	2	5	4	
Bag house (Dp inches)	4.2	4	4.5	4.2	
Exit gas Temperature (F)	320	321	314	318	
Output (MWh-net)	54.43	54.84	54.63	54.63	
Soot Blowing	--	--	--		
Ammonia Flow (lb/hour)	86	85	85	85	
MPU Fireman	Chip Luedtke and Dan Wier				

NOTES: B9 is found on graphic 103, turbine is on graphic 140.

B9 suppling all extraction steam, the Diesel not online.

Boiler Stack Test Operating Data

Date:September 28, 2011	Boiler: B-09	Recorded by: Thomas E. Reed
Test: Ammonia	Run: No. 3	Testing by: Platt Environmental Services, Inc.
Methods: USEPA Methods 1, 2, and 3A, 40CFR60, Appendix A and CTM-027		

Parameter	Start	Mid	Stop	Avg.	Net
Time	15:30		16:42		**1:12**
Coal Scale (A.)	382157		401681		**19,524**
Coal Scale (B.)	953278		972557		**19,279**
Coal Scale (C.)	910394		929567		**19,173**
Total Pounds of Fuel					**57,976**
Pounds of fuel per hour					**48,313**
Limestone (Klbs/hr)	12.5	12.6	13.4	12.8	
Limestone Scale (lbs)	345586		361289		**15,703**
MW Totals (MWh)	5785		5857		**72**
Output (MWh-gross)	59.96	59.49	59.44	59.63	
Steam Flow (Klbs/hour)	464	460	460	461	
Feed Water (Klbs/hr)	451	448	448	449	
Boiler Master (psig)	1462.6	1458.6	1460.3	1460.5	
Fuel Master (Klbs/hr)	47.9	48.2	48.0	48.0	
NOx (ppm)	35	30	36	34	
Differential Freeboard	6.0	6.0	6.0	6.0	
Bed Temperature (F)	1640	1661	1664	1655	
Bed Depth (in.)	25	25	26	25	
PA Flow (Klbs/hr)	310	313	312	312	
SA Flow (Klbs/hr)	250.3	249.5	250.3	250.0	
Oxygen (%)	3.00	2.92	3.05	2.99	
Opacity (%)	2.45	2.67	2.34	2.49	
Carbon Monoxide (ppm)	5	5	2	4	
Bag house (Dp inches)	3.2	3.1	3.4	3.2	
Exit gas Temperature (F)	315	315	316	315	
Output (MWh-net)	55.04	54.62	54.73	54.80	
Soot Blowing	--	--	--		
Ammonia Flow (lb/hour)	99	103	98	100	
MPU Fireman	Dan Wier				

NOTES: B9 is found on graphic 103, turbine is on graphic 140.

B9 suppling all extraction steam, the Diesel not online.

Boiler Stack Test Operating Data

Date:September 29, 2011	Boiler: B-09	Recorded by: Thomas E. Reed
Test: Sulfuric Acid Mist	Run: No. 1	Testing by: Platt Environmental Services, Inc.
Methods: USEPA Methods 1, 2, and 3A, 40CFR60, Appendix A, and Consol Method 8A		

Parameter	Start	Mid	Stop	Avg.	Net
Time	9:44		10:48		**1:04**
Coal Scale (A.)	535828		553348		**17,520**
Coal Scale (B.)	105202		122589		**17,387**
Coal Scale (C.)	60934		78222		**17,288**
Total Pounds of Fuel					**52,195**
Pounds of fuel per hour					**48,933**
Limestone (Klbs/hr)	9.6	10.8	9.5	10.0	
Limestone Scale (lbs)	472540		482939		**10,399**
MW Totals (MWh)	6313		6377		**64**
Output (MWh-gross)	58.75	59.94	59.42	59.37	
Steam Flow (Klbs/hour)	458	463	460	460	
Feed Water (Klbs/hr)	448	443	448	446	
Boiler Master (psig)	1461.8	1461.1	1460.8	1461.2	
Fuel Master (Klbs/hr)	48.5	48.5	49.1	48.7	
BARI (Klbs/hr)	--	--	--	#DIV/0!	
Differential Freeboard	7.5	7.5	7.8	7.6	
Bed Temperature (F)	1651	1651	1643	1648	
Bed Depth (in.)	25	26	26	26	
PA Flow (Klbs/hr)	352	344	355	350	
SA Flow (Klbs/hr)	198.8	202.4	205.5	202.2	
Oxygen (%)	2.5	2.54	2.82	2.62	
Opacity (%)	2.23	2.61	1.90	2.25	
Carbon Monoxide (ppm)	6	3	5	5	
Bag house (Dp inches)	4.2	4.2	4.3	4.2	
Exit gas Temperature	311	312	317	313	
Output (MWh-net)	54.73	54.94	54.05	54.57	
Soot Blowing	--	--	--		
Ammonia Flow (lb/hour)	--	--	--	#DIV/0!	
MPU Fireman	Evan Moen				

NOTES: B9 is found on graphic 103, turbine is on graphic 140.

B9 suppling all extraction steam, the Diesel not online.

Boiler Stack Test Operating Data

Date:September 29, 2011	Boiler: B-09	Recorded by: Thomas E. Reed
Test: Sulfuric Acid Mist	Run: No. 2	Testing by: Platt Environmental Services, Inc.
Methods: USEPA Methods 1, 2, and 3A, 40CFR60, Appendix A, and Consol Method 8A		

Parameter	Start	Mid	Stop	Avg.	Net
Time	11:40		12:52		**1:12**
Coal Scale (A.)	567170		587344		**20,174**
Coal Scale (B.)	136264		156213		**19,949**
Coal Scale (C.)	91798		111613		**19,815**
Total Pounds of Fuel					**59,938**
Pounds of fuel per hour					**49,948**
Limestone (Klbs/hr)	9.1	9.5	10.3	9.6	
Limestone Scale (lbs)	490966		502409		**11,443**
MW Totals (MWh)	6428		6498		**70**
Output (MWh-gross)	58.72	58.51	60.16	59.13	
Steam Flow (Klbs/hour)	456	455	465	459	
Feed Water (Klbs/hr)	437	439	444	440	
Boiler Master (psig)	1459.4	1459.1	1462.6	1460.4	
Fuel Master (Klbs/hr)	49.4	49.7	49.7	49.6	
BARI (Klbs/hr)	--	--	--	#DIV/0!	
Differential Freeboard	8.2	8.5	8.5	8.4	
Bed Temperature (F)	1649	1637	1644	1643	
Bed Depth (in.)	28	29	28	28	
PA Flow (Klbs/hr)	360	352	356	356	
SA Flow (Klbs/hr)	186.4	186.4	190.1	187.6	
Oxygen (%)	2.63	2.6	2.47	2.57	
Opacity (%)	2.83	2.36	2.36	2.52	
Carbon Monoxide (ppm)	0	1	0	0	
Bag house (Dp inches)	4.7	2.9	2.8	3.5	
Exit gas Temperature	317	318	320	318	
Output (MWh-net)	53.53	53.81	55.13	54.16	
Soot Blowing	--	--	--		
Ammonia Flow (lb/hour)	--	--	--	#DIV/0!	
MPU Fireman	Evan Moen				

NOTES: B9 is found on graphic 103, turbine is on graphic 140.

B9 suppling all extraction steam, the Diesel not online.

Boiler Stack Test Operating Data

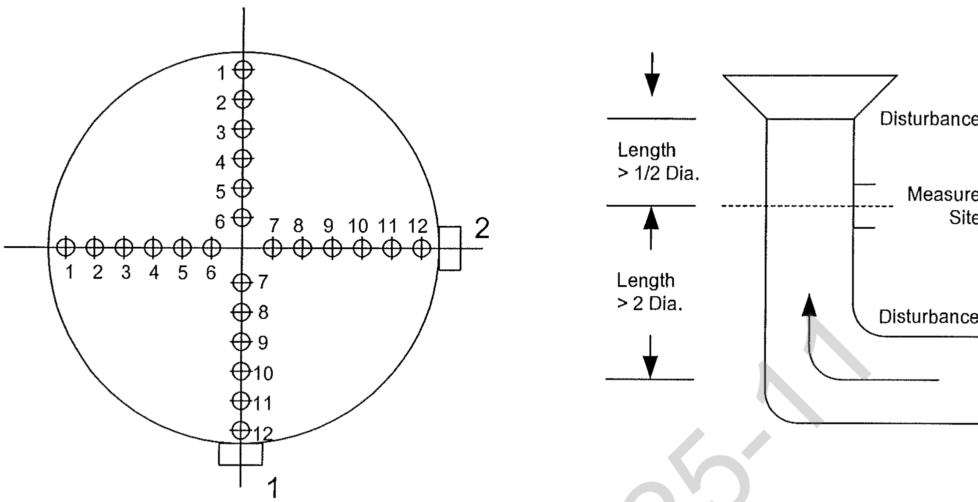
Date:September 29, 2011	Boiler: B-09	Recorded by: Thomas E. Reed
Test: Sulfuric Acid Mist	Run: No. 3	Testing by: Platt Environmental Services, Inc.
Methods: USEPA Methods 1, 2, and 3A, 40CFR60, Appendix A, and Consol Method 8A		

Parameter	**Start**	**Mid**	**Stop**	Avg.	**Net**
Time	13:25		14:27		**1:02**
Coal Scale (A.)	596813		613845		**17,032**
Coal Scale (B.)	165607		182459		**16,852**
Coal Scale (C.)	120964		137698		**16,734**
Total Pounds of Fuel					**50,618**
Pounds of fuel per hour					**48,985**
Limestone (Klbs/hr)	11.5	12	12.7	12.1	
Limestone Scale (lbs)	508573		521578		**13,005**
MW Totals (MWh)	6532		6596		**64**
Output (MWh-gross)	61.37	60.98	60.9	61.08	
Steam Flow (Klbs/hour)	471	469	469	470	
Feed Water (Klbs/hr)	457	451	456	455	
Boiler Master (psig)	1472.9	1464.8	1454.8	1464.2	
Fuel Master (Klbs/hr)	49.5	48.7	48.7	49.0	
BARI (Klbs/hr)	--	--	--	#DIV/0!	
Differential Freeboard	7.5	7.4	7.5	7.5	
Bed Temperature (F)	1652	1665	1669	1662	
Bed Depth (in.)	27	27	28	27	
PA Flow (Klbs/hr)	352	354	352	353	
SA Flow (Klbs/hr)	194.9	202.4	208.7	202.0	
Oxygen (%)	2.38	2.49	2.69	2.52	
Opacity (%)	2.53	2.25	1.84	2.21	
Carbon Monoxide (ppm)	1	0	0	0	
Bag house (Dp inches)	3.3	3.5	3.5	3.4	
Exit gas Temperature	322	321	320	321	
Output (MWh-net)	56.23	55.90	55.30	55.81	
Soot Blowing	--	--	--		
Ammonia Flow (lb/hour)	--	--	--	#DIV/0!	
MPU Fireman	Evan Moen				

NOTES: B9 is found on graphic 103, turbine is on graphic 140.

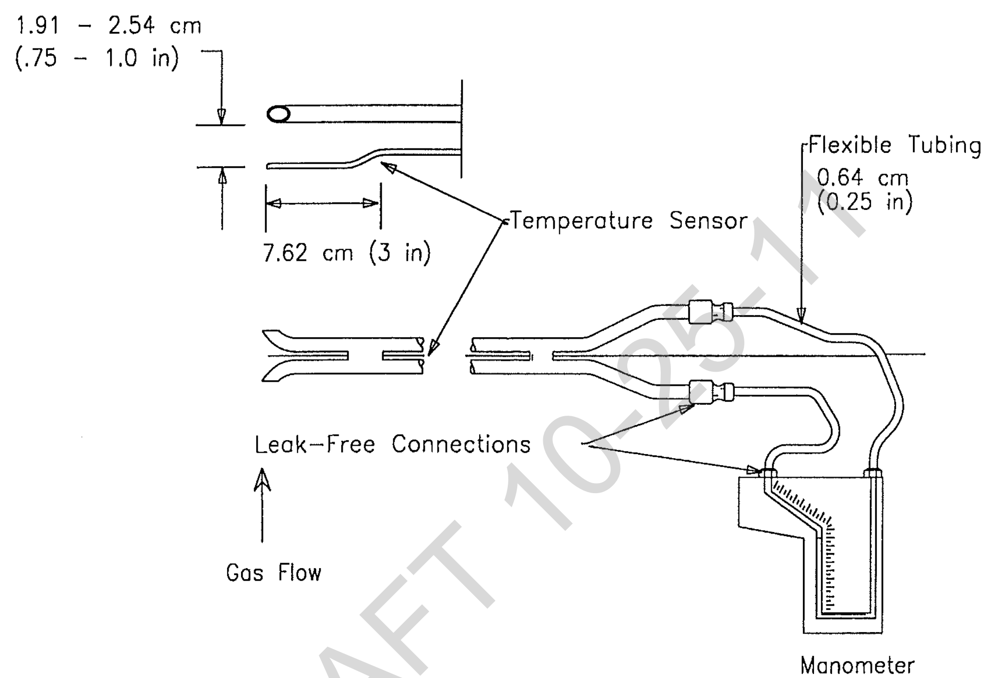
B9 suppling all extraction steam, the Diesel not online.

EQUAL AREA TRAVERSE FOR ROUND DUCTS

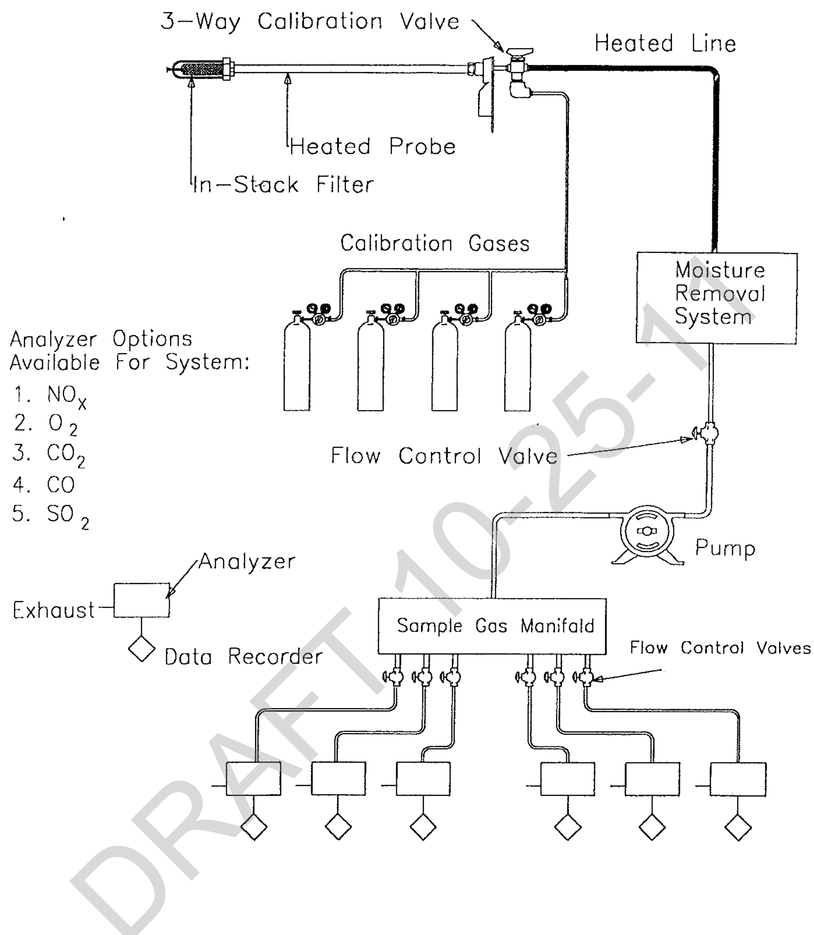


Job:	Manitowoc Public Utilities
	Manitowoc, Wisconsin
Date:	September 28 and 29, 2011
Unit No:	Boiler B09
Test Location:	Outlet Duct
Duct Diameter:	9.0 Feet
Duct Area:	63.62 Square Feet
No. Points Across Diameter:	24
No. of Ports:	2
Port Length:	15.0 Inches

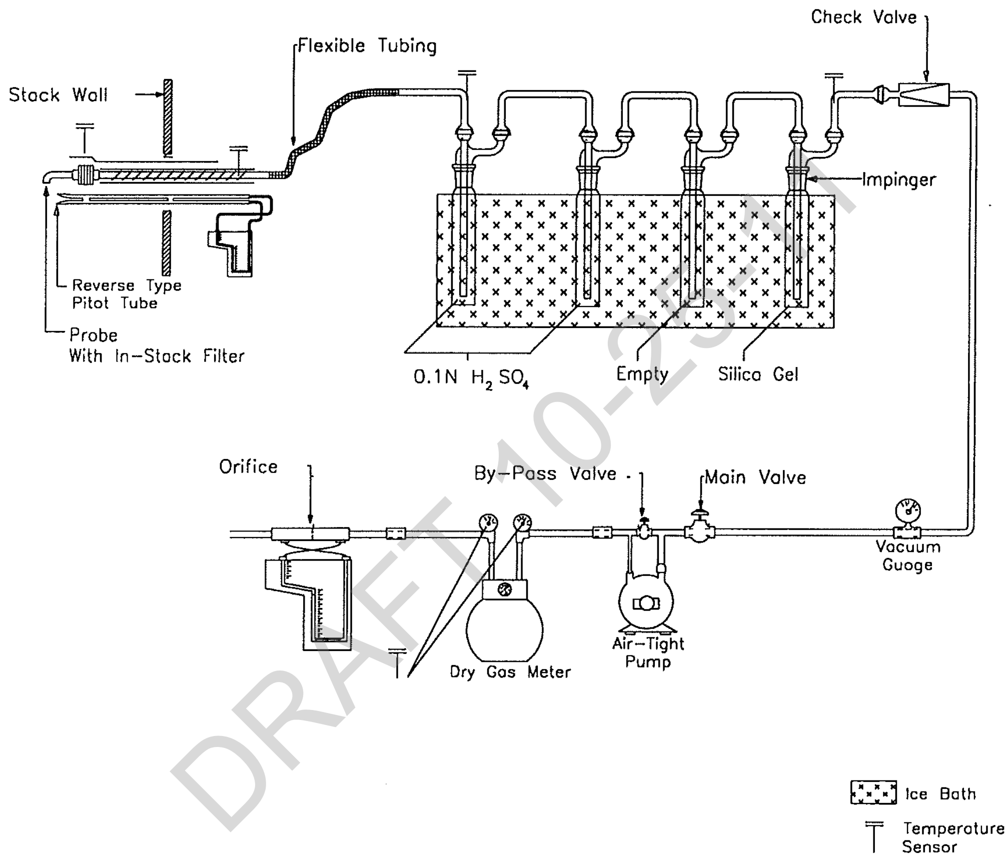
USEPA Method 2 - S-Type Pitot Tube Diagram



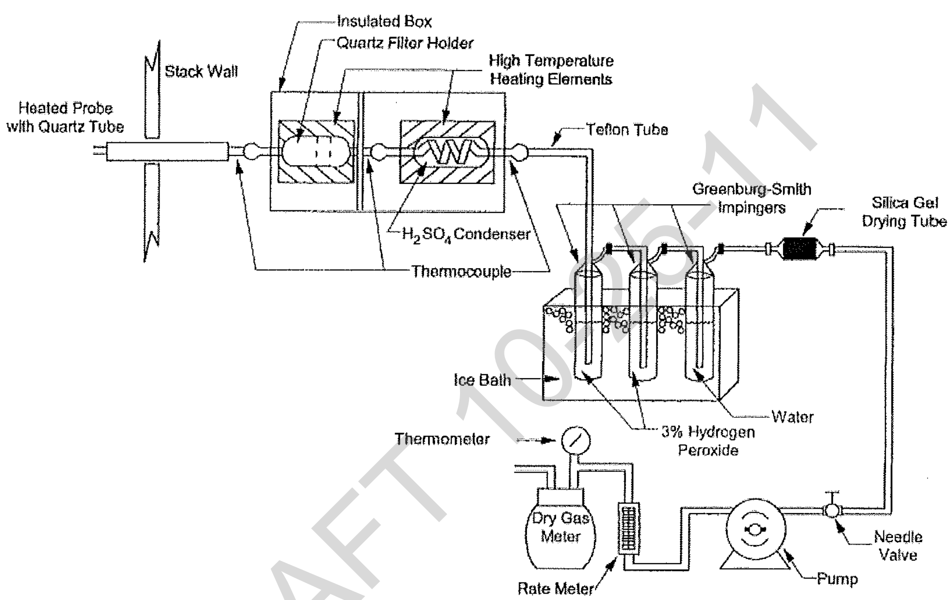
USEPA Method 3A Extractive Gaseous Sampling Diagram



USEPA Conditional Test Method 027 - Ammonia Sample Train Diagram



Consol Controlled Condensate – Sulfuric Acid Mist Sample Train Diagram



Client: Manitowoc Public Utilities
Facility: Manitowoc Generating Station
Test Location: Boiler B09 Outlet Duct
Run: 1
Date: 9/28/2011

Dry Molecular Weight

$$Md = 0.44 \times (\%CO_2) + 0.32 \times (\%O_2) + 0.28 \times \%N_2$$

$\%CO_2 =$ 14.0 $\%O_2 =$ 5.3 $\%N_2 =$ 80.7

Md = 30.45

Wet Molecular Weight

$$Ms = Md \times (1\text{-}Bws) + (18.0 \times Bws)$$

Md = 30.45 Bws = 0.066

Ms = 29.63

Meter Volume at Standard Conditions

$$Vm(std) = 17.647 \times Y \times Vm \times \frac{(Pbar + DH/13.6)}{Tm}$$

Y = 1.015 Vm = 64.915 Pbar = 29.09
DH = 3.38 Tm = 527.5

Vm(std) = 64.674

Volume of Water Vapor Condensed

$$Vw(std) = 0.0471 \times (\text{net } H_2O \text{ gain})$$

Net H_2O = 96.9

Vw(std) = 4.564

Moisture Content

$$Bws = \frac{Vwc(std)}{Vwc(std) + Vm(std)}$$

Vw(std) = 4.564 Vm(std) = 64.674

Bws = 0.066

Client:	Manitowoc Public Utilities
Facility:	Manitowoc Generating Station
Test Location:	Boiler B09 Outlet Duct
Run:	1
Date:	9/28/2011

Average Duct Velocity

$$Vs = 85.49 \times Cp \times \text{Sqrt DP (avg)} \times (\text{Ts (avg)}/(\text{Ps} \times \text{Ms}))^{1/2}$$

Cp = 0.840 Ts (avg) = 801.3 Sqrt DP (avg): 0.870
Ps = 29.10 Ms = 29.63

Vs = 60.20

Volumetric Flow Rate (Actual Basis)

$$Q = Vs \times A \times 60$$

Vs = 60.20 A = 63.617

Q = 229778

Volumetric Flow Rate (Standard Basis)

$$Qstd = 17.647 \times Q \times \frac{Ps}{\text{Ts (avg)}}$$

Q = 229778 Ps = 29.10 Ts (avg) = 801.3

Qstd = 147282

Volumetric Flow Rate (Standard Dry Basis)

$$Qstd(dry) = Qstd \times (1-Bws)$$

Qstd = 147282 Bws = 0.066

Qstd(dry) = 137574

Isokinetic Variation:

$$\%ISO = \frac{0.0945 \times Ts \times Vm(std)}{Vs \times \theta \times An \times Ps \times (1-Bws)}$$

Ts = 801.3 Vm(std) = 64.674 Vs = 60.198
An = 0.0005074 θ = 60.0 Ps = 29.10
Bws = 0.066

%ISO = 98.3

ICR M5B/OTM28 2/2/10

Volumetric Flow Rate Example Calculations

Client: Manitowoc Public Utilities
Plant: Manitowoc, WI
Location: Boiler B09 Outlet Duct
Run: High Load Load, Run Pre 1
Date: 09/29/11

Moisture Content

$$Bws = \frac{e' - AP\,(t-t')}{P}$$

where: e' = saturated vapor pressure of water, in. Hg, at the wet bulb temperature, t'
$A = 3.67 \times 10^{-4}(1+0.00064\,(t'-32))$
P = absolute pressure, in. Hg, in the duct
t = dry bulb temperature, ^{o}F
t' = wet bulb temperature, ^{o}F

Bws = 0.081

Dry Molecular Weight

$Md = 0.44 \times (\%CO_2) + 0.32 \times (\%O_2) + 0.28 \times \%N_2$

$\%CO_2$ = 14.0 $\%O_2$ = 5.2 $\%N_2$ = 80.8

Md = 30.45

Wet Molecular Weight

Ms = Md x (1-Bws) + (18.0 x Bws)

Md = 30.45 Bws = 0.081

Ms = 29.44

Average Duct Velocity

$Vs = 85.49 \times Cp \times Sqrt\,\Delta P\,(avg) \times (Ts\,(avg)/ (Ps \times Ms))^{1/2}$

Cp = 0.840 Ts (avg) = 798.5 Sqrt ΔP avg: 0.824
Ps = 29.06 Ms = 29.44

Vs = 57.16

Volumetric Flow Rate

Q (Actual Basis)= Vs x A x 60

Vs = 57.16 A = 63.617

Q = 218193 acfm

$$Qs\ (Standard\ Basis) = 17.647 \times Q \times \frac{Ps}{460 + Ts\,(avg)}$$

Q = 218193 Ps = 29.06 Ts (avg) = 798.5

Qs = 140146 scfm

Qs (Standard Basis)= scfm x 60 min/hr

Qs = 8408786 scfh

$$Qs\ (Standard\ Basis) = (1 - Bws) \times 17.647 \times \frac{Q \times Ps}{460 + Ts\,(avg)}$$

Q = 218193 Ps = 29.06 Ts (avg) = 798.5 1-Bws = 0.919

Qs = 128795 dscfm

MOSTARDI PLATT

Calculations for Ammonia by CTM 027

Concentration

$$\frac{\text{lbs NH4}}{\text{dscf}} = \frac{mg\ \text{NH4 in sample}}{4.536 \times 10^5 \times \text{dscf}}$$

where:

$4.536 \times 10^5 = mg/\text{lb}$

$\text{dscf} = \text{Volume of gas sampled}$

Parts Per Million

$$\text{ppm NH4} = \frac{\text{lbs NH4}}{\text{dscf}} \div \frac{18.04}{385 \times 10^6}$$

where:

385 = Volume of 1 lb mole of gas at 68°F and 29.92 in. Hg

$10^6 = \text{Conversion of ppm v/v}$

Emission Rate

lbs NH4/dscf × dscfm × 60 min/hr = lbs/hr NH4

MOSTARDI PLATT

Calculations for Sulfuric Acid Mist

$$V_{m(std)} = 17.647\ V_m\ Y \frac{P_{bar} + \frac{\Delta H}{13.6}}{T_m}$$

$$C_{H_2SO_4} = 1.0811 \times 10^{-4} \frac{(V_t - V_{tb})\ N \left(\frac{V_{soln}}{V_a}\right)}{V_{m(std)}}$$

$$\text{ppm } H_2SO_4 = 3.9289 \times 10^6 C_{H_2SO_4} \quad (\text{expressed as } H_2SO_4)$$

Where:

$C_{H_2SO_4}$ = Concentration of sulfuric acid (including sulfur trioxide), dry basis, corrected to standard conditions, lb/dscf

N = Normality of barium chloride titrant, meq/ml

P_{bar} = Barometric pressure at the exit of the dry gas meter, inches of mercury

P_{std} = Standard pressure, 29.92 inches of mercury

T_{std} = Standard temperature, 528 °R

17.647 = T_{std}/P_{std}

V_a = Volume of sample aliquot titrated, ml

T_m = Dry gas meter average temperature, °R

V_m = Dry gas volume measured by dry gas meter, dcf

$V_{m(std)}$ = Dry gas volume measured by dry gas meter, corrected to standard conditions, dscf

V_{soln} = Total volume of solution in which the sulfuric acid sample is contained, ml

V_t = Volume of barium perchlorate titrant used for the sample, ml

V_{tb} = Volume of barium perchlorate titrant used for the blank, ml

Y = Dry gas meter calibration factor

ΔH = Average pressure differential across the orifice meter, inches of water

13.6 = Specific gravity of mercury

1.0811×10^{-4} = Equivalent weight of sulfuric acid, lb/g-meq

3.9289×10^6 = $\frac{\text{dscf}}{\text{lb}}$ of sulfuric acid

MOSTARDI PLATT

Isokinetic Calculation Formulas

1. $V_{w(std)} = V_{lc}\left(\frac{\rho_w}{M_w}\right)\left(\frac{RT_{std}}{P_{std}}\right) = K_2 V_{lc}$

2. $V_{m(std)} = V_m Y \left(\frac{T_{std}}{T_m}\right)\left(\frac{(P_{bar} + (\frac{\Delta H}{13.6}))}{P_{std}}\right) = K_1 V_m Y \frac{(P_{bar} + (\frac{\Delta H}{13.6}))}{T_m}$

3. $B_{ws} = \frac{V_{w(std)}}{(V_{m(std)} + V_{w(std)})}$

4. $M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2)$

5. $M_s = M_d(1 - B_{ws}) + 18.0(B_{ws})$

6. $C_a = \frac{m_a}{V_a \rho_a}$

7. $W_a = C_a V_{aw} \rho_a$

8. $C_{acf} = 15.43 K_i \left(\frac{m_n P_s}{V_{w(std)} + V_{m(std)} \; T_s}\right)$

9. $C_S = (15.43 \text{ grains/gram})\ (m_n / V_{m(std)})$

10. $v_s = K_p C_p \sqrt{\frac{\Delta P \; T_s}{P_s M_s}}$

11. $Q_{acfm} = v_s A(60_{sec/min})$

12. $Q_{sd} = (3600_{sec/hr})(1 - B_{ws})\ v_s \left(\frac{T_{std} P_s}{T_s P_{std}}\right) A$

13. $E \text{ (emission rate, lbs/hr)} = Q_{std}(C_s / 7000 \text{ grains/lb})$

14. $IKV = \frac{T_s V_{m(std)} P_{std}}{T_{std} v_s \theta A_n P_s 60(1 - B_{ws})} = K_4 \frac{T_s V_{m(std)}}{P_s v_s A_n \theta (1 - B_{ws})}$

15. $\%EA = \left(\frac{\%O_2 - (0.5\,\%CO)}{0.264\,\%N_2 - (\%O_2 - 0.5\,\%CO)}\right) \times 100$

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Isokinetic Nomenclature

A = Cross-sectional area of stack or duct, square feet
A_n = Cross-sectional area of nozzle, square feet
B_{ws} = Water vapor in gas stream, by volume
C_a = Acetone blank residue concentration, g/g
C_{acf} = Concentration of particulate matter in gas stream at actual conditions, gr/acf
C_p = Pitot tube coefficient
C_s = Concentration of particulate matter in gas stream, dry basis, corrected to standard conditions, gr/dscf
IKV = Isokinetic sampling variance, must be 90.0 % ≤ IKV ≤ 110.0%
M_d = Dry molecular weight of gas, lb/lb-mole
M_s = Molecular weight of gas, wet basis, lb/lb-mole
M_w = Molecular weight of water, 18.0 lb/lb-mole
m_a = Mass of residue of acetone after evaporation, grams
P_{bar} = Barometric pressure at testing site, inches mercury
P_g = Static pressure of gas, inches mercury (inches water/13.6)
P_s = Absolute pressure of gas, inches mercury = $P_{bar} + P_g$
P_{std} = Standard absolute pressure, 29.92 inches mercury
Q_{acfm} = Actual volumetric gas flow rate, acfm
Q_{sd} = Dry volumetric gas flow rate corrected to standard conditions, dscfh
R = Ideal gas constant, 21.85 inches mercury cubic foot/°R-lb-mole
T_m = Dry gas meter temperature, °R
T_s = Gas temperature, °R
T_{std} = Absolute temperature, 528°R
V_a = Volume of acetone blank, ml
V_{aw} = Volume of acetone used in wash, ml
W_a = Weight of residue in acetone wash, grams
m_n = Total amount of particulate matter collected, grams
V_{1c} = Total volume of liquid collected in impingers and silica gel, ml
V_m = Volume of gas sample as measured by dry gas meter, dcf
$V_{m(std)}$ = Volume of gas sample measured by dry gas meter, corrected to standard conditions, dscf
v_s = Gas velocity, ft/sec
$V_{w(std)}$ = Volume of water vapor in gas sample, corrected to standard conditions, scf
Y = Dry gas meter calibration factor
ΔH = Average pressure differential across the orifice meter, inches water
Δp = Velocity head of gas, inches water
ρ_a = Density of acetone, 0.7855 g/ml (average)
ρ_w = Density of water, 0.002201 lb/ml
θ = Total sampling time, minutes
K_1 = 17.647 °R/in. Hg
K_2 = 0.04707 ft^3/ml
K_4 = 0.09450/100 = 0.000945
K_p = Pitot tube constant, $85.49 \frac{ft}{sec}\left[\frac{(lb/lb-mole)(in.Hg)}{(^\circ R)(in.H_2O)}\right]^{1/2}$
%EA = Percent excess air
$\%CO_2$ = Percent carbon dioxide by volume, dry basis
$\%O_2$ = Percent oxygen by volume, dry basis
%CO = Percent carbon monoxide by volume, dry basis
$\%N_2$ = Percent nitrogen by volume, dry basis
0.264 = Ratio of O_2 to N_2 in air, v/v
28 = Molecular weight of N_2 or CO
32 = Molecular weight of O_2
44 = Molecular weight of CO_2
13.6 = Specific gravity of mercury (Hg)

MOSTARDI PLATT

Volumetric Flow Nomenclature

A = Cross-sectional area of stack or duct, ft^2
B_{ws} = Water vapor in gas stream, proportion by volume
C_p = Pitot tube coefficient, dimensionless
M_d = Dry molecular weight of gas, lb/lb-mole
M_s = Molecular weight of gas, wet basis, lb/lb-mole
M_w = Molecular weight of water, 18.0 lb/lb-mole
P_{bar} = Barometric pressure at testing site, in. Hg
P_g = Static pressure of gas, in. Hg (in. H_2O/13.6)
DH= Static pressure of gas, in.H_2O
P_s = Absolute pressure of gas, in. Hg = $P_{bar} + P_g$
P_{std} = Standard absolute pressure, 29.92 in. Hg
Acfm = Actual volumetric gas flow rate
Scfm= Volumetric gas flow rate, corrected to standard conditions
Dscfm = Standard volumetric flow rate, corrected to dry conditions
R = Ideal gas constant, 21.85 in. Hg-ft^3/°R-lb-mole
T_s = Average stack gas temperature, °F
T_m = Average dry gas meter temperature, °F
T_{std} = Standard absolute temperature, 528°R
v_s = Gas velocity, ft/sec
Vm(std)= Volume of gas sampled, corrected to standard conditions, scf
Vw(std) = Volume of water vapor in gas sample, corrected to standard conditions, scf
Vlc= Volume of liquid collected
Y = Dry gas meter calibration factor
Δp = Velocity head of gas, in. H_2O
K_1 = 17.647 °R/in. Hg
%EA = Percent excess air
$\%CO_2$ = Percent carbon dioxide by volume, dry basis
$\%O_2$ = Percent oxygen by volume, dry basis
$\%N_2$ = Percent nitrogen by volume, dry basis
0.264 = Ratio of O_2 to N_2 in air, v/v
0.28 = Molecular weight of N_2 or CO, divided by 100
0.32 = Molecular weight of O_2 divided by 100
0.44 = Molecular weight of CO_2 divided by 100
13.6 = Specific gravity of mercury (Hg)

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Volumetric Air Flow Calculations

$$Vm\,(std) = 17.647 \times Vm \times \left[\frac{(P_{bar} + (\frac{DH}{13.6}))}{(460 + Tm)}\right] \times Y$$

$$Vw\,(std) = 0.0471 \times Vlc$$

$$Bws = \left[\frac{Vw\,(std)}{Vw\,(std) + Vm\,(std)}\right]$$

$$Md = (0.44 \times \%CO_2) + (0.32 \times \%O_2) + [0.28 \times (100 - \%CO_2 - \%O_2)]$$

$$Ms = Md \times (1 - Bws) + (18 \times Bws)$$

$$Vs = \sqrt{\frac{(Ts + 460)}{Ms \times Ps}} \times \sqrt{DP} \times Cp \times 85.49$$

$$Acfm = Vs \times \text{Area (of stack or duct)} \times 60$$

$$Scfm = Acfm \times 17.647 \times \left[\frac{Ps}{(460 + Ts)}\right]$$

$$Scfh = Scfm \times 60\frac{min}{hr}$$

Dscfm = Scfm x (1-Bws)

MOSTARDI PLATT

MOISTURE CALCULATIONS

$$V_{wc(std)} = \frac{(V_f - V_i)\,\rho_w\ R\ T_{std}}{P_{std} M_w} = 0.04707(V_f - V_i)$$

$$V_{wsg(std)} = \frac{(W_f - W_i)\ R\ T_{std}}{P_{std}\ M_w} = 0.04715\ (W_f - W_i)$$

$$V_{m(std)} = 17.64\ \ V_m\ Y \frac{P_{bar} + \dfrac{\Delta H}{13.6}}{T_m}$$

$$B_{ws} = \frac{V_{wc(std)} + V_{wsg(std)}}{V_{wc(std)} + V_{wsg(std)} + V_{m(std)}}$$

Where:

B_{ws} = Water vapor in gas stream, proportion by volume
M_w = Molecular weight of water, 18.015 lb/lb-mole
P_{bar} = Barometric pressure at the testing site, in. Hg
P_{std} = Standard absolute pressure, 29.92 in. Hg
R = Ideal gas constant, 0.048137 (in. Hg)(ft^3)/(g-mole)(°R) = [21.8348(in. Hg)(ft^3)/(lb-mole)(°R)]/453.592 g-mole/lb-mole
T_m = Absolute average dry gas meter temperature, °R
T_{std} = Standard absolute temperature, 528 °R
V_f = Final volume of condenser water, ml
V_i = Initial volume of condenser water, ml
V_m = Dry gas volume measured by dry gas meter, dcf
$V_{m(std)}$ = Dry gas volume measured by dry gas meter, corrected to standard conditions, scf
$V_{wc(std)}$ = Volume of condensed water vapor, corrected to standard conditions, scf
$V_{wsg(std)}$ = Volume of water vapor collected in silica gel, corrected to standard conditions, scf
W_f = Final weight of silica gel, g
W_i = Initial weight of silica gel, g
Y = Dry gas meter calibration factor
ΔH = Average pressure exerted on dry gas meter outlet by gas sample bag, in. H_2O
ρ_w = Density of water, 0.9982 g/ml
13.6 = Specific gravity of mercury (Hg)
17.64 = T_{std}/P_{std}
0.04707 = ft^3/ml   0.04715 = ft^3/g

Coal Emission Rate Calculations

A pollutant emission rate (E), expressed as pounds of pollutant per million Btu heat input from the fuel combusted can be calculated by several methods as follows:

A. $C = C_s/7000$ where, C = pollutant concentration, lb/dscf
c_s = pollutant concentration, grains/dscf

B. If fuel flow is monitored and the fuel combusted during the test is sampled and analyzed for gross calorific value, then:

$$E = \frac{Q_{sd} C}{\text{fuel flow rate (lb/hr) GCV}} \times 10^6$$

where, E = lbs per million Btu
GCV = gross calorific value, Btu/lb
Q_{sd} = dry volumetric gas flow at standard conditions, dscf/hr

C. If an integrated gas sample is taken during the test and analyzed for $\%CO_2$ or $\%O_2$, dry basis by volume, with an approved USEPA Method 3 or 3A gas analyzer, then

$$E = C F_c \frac{100}{(\%CO_2)} \quad \text{or,} \quad E = C F \frac{20.9}{(20.9 - \%O_2)} \quad \text{where,}$$

$\%CO_2$ and $\%O_2$ are expressed as percent values:

F_c = a factor representing a ratio of the volume of carbon dioxide generated to the calorific value of the fuel combusted, 1800 scf CO_2/million Btu for bituminous.
F = a factor representing a ratio of the volume of dry flue gases generated to the calorific value of the fuel combusted, 9780 dscf/million Btu for bituminous.

D. If fuel sample increments are taken and composited during the test and an ultimate analysis is performed and the GCV is determined, then

$$F_c = \frac{321 \times 10^3 (\%C)}{GCV} \quad \text{where, \%C = carbon content by weight expressed as percent}$$

$$F = \frac{[3.64(\%H) + 1.53(\%C) + 0.57(\%S) + 0.14(\%N) - 0.46(\%O_2)]}{GCV} \times 10^6$$

1. H = Hydrogen, percent
2. C = Carbon, percent
3. S = Sulfur, percent
4. N = Nitrogen, percent
5. O = Oxygen, percent

LABORATORY REPORT

TEI Analytical, Inc.
7177 N. Austin
Niles, IL 60714-4617
847-647-1345

PREPARED FOR:

Jim Platt
Platt Environmental Services Inc.
1905 Mount Prospect Rd, Ste C
Des Plaines, IL 60018

Report #: 88075
Report Date: 10/7/2011
Sample Received:
10/3/11 12:00

M113908

TEI Number	Sample	Ammonia as NH4 (CTM-027) mg	Date Performed
88075	001	4.76	10/5/2011
88076	002	<0.2	10/5/2011
88077	003	3.66	10/5/2011
88078	004	<0.2	10/5/2011
88079	005	2.60	10/5/2011
88080	006	<0.2	10/5/2011
88081	007	<0.2	10/5/2011

G. E. O'Neill

Gayle E. O'Neill, Ph.D.

Platt Environmental Services, Inc.

Chain-of-Custody Form

Project Number: M113908	Date Results Required:
Client: Manitowoc Public Utilities	TAT Required:
Plant/Test Location: Manitowoc, WI	Project Supervisor: ALS

Sample Number	Sample Date	Sample Point Identification	# of Conts	Sub Lab	Analysis Required	Volume, mls
001	9/28/11	Test 1- Imp 1	1	TEI	CTM027-Ammonia	217
002	9/28/11	Test 1- Imp 2	1	TEI	CTM027-Ammonia	144
003	9/28/11	Test 2- Imp 1	1	TEI	CTM027-Ammonia	229
004	9/28/11	Test 2- Imp 2	1	TEI	CTM027-Ammonia	139
005	9/28/11	Test 3- Imp 1	1	TEI	CTM027-Ammonia	274
006	9/28/11	Test 3- Imp 2	1	TEI	CTM027-Ammonia	147
007	9/28/11	H_2SO_4 Reagent Blank	1	TEI	CTM027-Ammonia	120
008						
009						
010						
011						
012						
013						
014						
015						
016						
017						
018						
019						
020						

Delivered to Lab by:	Date/Time:	Received by:	Date/Time:	Processed by:	Date/Time:
[illegible]	10/3/11	[illegible]	10/3/11 1200		

Laboratory Notes:

Barium-Thorin Titrations

Project/Project Number: Manitowoc M113908 Analyst: JMG Date:

Barium Titrant Standardization	Run No. 1	Run No. 2	Run No. 3
Volume 0.01 N H_2SO_4 titrated (ml)	20	20.	
Volume $BaCl_2$ added (ml)	19.7	19.5	
Calculated $BaCl_2$ normality	0.0102	0.0103	

Average $BaCl_2$ normality = 0.0102 N
Standardization Blank (25 ml Water + 100 ml isopropanol) = 0.0 ml ; Must be <0.5 ml.

Sample Number	Sample Date	Sample Description	Total Volume	Sample Aliquot	Titrant Volume for Sample Final Reading - Initial Reading = V_t ml	Titrant Volume Corrected for Blank (V_t - V_{tb}) ml
Ammonium Sulfate Controls	9/29	Test 1 Coil Rinse IPA	100	25	0.3 - 0 = 0.3 0.6 - 0.3 = 0.3 Average = 0.3	0.3
	9/29	Test 2 Coil Rinse IPA	100	25	0.8 - 0.6 = 0.2 1.1 - 0.8 = 0.3 Average = 0.25	0.25
	9/29	Test 3 Coil Rinse IPA	100	25	1.6 - 1.4 = 0.2 1.8 - 1.6 = 0.2 Average = 0.2	0.2
	9/29	Test 1 QA/QC	100	9mL sample 1mL 0.01N H_2SO_4	17.2 - 16.0 = 1.2 18.4 - 17.2 = 1.2 Average = 1.2	1.2
					- = - = Average =	
					- = - = Average =	
		H_2O_2 Reagent Blank			- = - = Average =	V_{tb}

* All titrations must be performed in replicate with agreement of 0.1% or 0.2 ml, whichever is larger.

Platt Environmental Services, Inc.

Chain-of-Custody Form

Project Number: M 113908	Date Results Required:
Client: MANITOWOC PUBLIC UTILITIES	TAT Required:
Plant/Test Location: Manitowoc, WI	Project Supervisor: ALS

Sample Number	Sample Date	Sample Point Identification	# of Conts	Sub Lab	Analysis Required	Volume, mls
001	9/28	ctm 027 Run 1	3			
002	9/28	ctm 027 Run 2	3			
003	9/28	ctm 027 Run 3	3			
004	9/28	0.1N H_2SO_4 FIELD BLANK	1			
005	9/29	CCS Run 1	2			
006	9/29	CCS Run 2	2			
007	9/29	CCS Run 3	2			
008	9/29	3% H_2O_2 Field Blank	1			
009						
010						
011						
012						
013						
014						
015						
016						
017						
018						
019						
020						

Delivered to Lab by:	Date/Time:	Received by:	Date/Time:	Processed by:	Date/Time:
[signature]	09/30/11 0930	[signature]	9/30/11	[signature]	10/5/11

Laboratory Notes:

LAB NO.	2011-1341-1
DATE REC'D	10/04/11
DATE SAMPLED	09/28/11
SAMPLED BY	CLIENT

STANDARD LABORATORIES, INC.

1530 N. Cullen Avenue
Evansville, IN 47715

MANITOWOC PUBLIC UTILITIES
P.O. BOX 1090
MANITOWOC, WI 54221

SAMPLE IDENTIFICATION

B9 AMMONIA STACK TEST
09/28/11

DATE REPORTED: 10/14/11

	% MOISTURE	% ASH	% VOLATILE	% FIXED CARBON	BTU/LBS	% SULFUR
AS REC'D	11.85	1.29	XXXX	XXXX	12896	5.00
DRY BASIS	------	1.46	XXXX	XXXX	14630	5.67
M-A-FREE					14847	

ULTIMATE ANALYSIS

	% As Received	Dry Basis
Carbon	71.87	81.53
Hydrogen	3.18	3.61
Nitrogen	1.25	1.42
Ash	1.29	1.46
Sulfur	5.00	5.67
Oxygen	5.56	6.31
Moisture	11.85	

NOTE: XXXX INDICATES ANALYSIS WAS NOT REQUESTED

Respectfully Submitted ______________________

FORM # 21

LAB NO. 2011-1341-2

DATE REC'D 10/04/11

DATE SAMPLED 09/29/11

SAMPLED BY CLIENT

STANDARD LABORATORIES,INC.

1530 N. Cullen Avenue
Evansville, IN 47715

MANITOWOC PUBLIC UTILITIES
P.O. BOX 1090
MANITOWOC, WI 54221

SAMPLE IDENTIFICATION

B9 SO3 STACK TEST
09/29/11

DATE REPORTED: 10/14/11

	% MOISTURE	% ASH	% VOLATILE	% FIXED CARBON	BTU/LBS	% SULFUR
AS REC'D	12.46	2.13	XXXX	XXXX	12414	4.29
DRY BASIS	------	2.43	XXXX	XXXX	14181	4.90
M-A-FREE					14534	

ULTIMATE ANALYSIS

	% As Received	Dry Basis
Carbon	65.42	74.73
Hydrogen	3.38	3.86
Nitrogen	1.07	1.22
Ash	2.13	2.43
Sulfur	4.29	4.90
Oxygen	11.25	12.86
Moisture	12.46	

NOTE: XXXX INDICATES ANALYSIS WAS NOT REQUESTED

Respectfully Submitted ______________________

FORM # 21

Client: Manitowoc Public Utilities
Facility: Manitowoc Generating Station
Test Location: Boiler B09 Outlet Duct

CTM027	**9/28/2011**	**CCS**	**9/29/2011**
% Hydrogen	3.61	% Hydrogen	3.86
% Carbon	81.53	% Carbon	74.73
% Sulfur	5.67	% Sulfur	4.90
% Nitrogen	1.42	% Nitrogen	1.22
% Oxygen	6.31	% Oxygen	12.86
HHV (Btu/lb)	14630	HHV (Btu/lb)	14181
Fd(dscf/MMBtu)=	9460.66	Fd(dscf/MMBtu)=	8845.32
Fc(scf/MMBtu)=	1788.87	Fc(scf/MMBtu)=	1691.58

METHOD 2 VOLUMETRIC FLOW DATA

Project Number	M113908	**Operating Level:**	Preliminary Flow
Client:	Manitowoc Public Utilities	**Run No.:**	1
Plant:	Manitowoc, WI	**Date:**	9/27/2011
Location:	Boiler B09 Outlet Duct	**Start Time:**	14:53
Pitot ID:	179-A	**End Time:**	15:12
Pitot Coefficient:	0.840	**RM Testers:**	ALS/rods
Probe Length:	10.0'	**Port Length:**	16"

Port	Point	DP (in. H_2O)	Sqrt. DP	Temp (°F)	Velocity (V)	Port	Point	DP (in. H_2O)	Sqrt. DP	Temp (°F)	Velocity (V)
A	1	0.25	0.5000	328.0	34.60	B	1	0.18	0.4243	328.0	29.36
A	2	0.26	0.5099	328.0	35.29	B	2	0.26	0.5099	328.0	35.29
A	3	0.26	0.5099	329.0	35.31	B	3	0.21	0.4583	329.0	31.74
A	4	0.24	0.4899	329.0	33.93	B	4	0.19	0.4359	329.0	30.19
A	5	0.21	0.4583	329.0	31.74	B	5	0.18	0.4243	330.0	29.40
A	6	0.23	0.4796	329.0	33.21	B	6	0.14	0.3742	330.0	25.93
A	7	0.22	0.4690	329.0	32.48	B	7	0.13	0.3606	330.0	24.98
A	8	0.19	0.4359	328.0	30.17	B	8	0.10	0.3162	330.0	21.91

Test Parameters

P_{bar} - Barometric pressure, inches Hg	29.15	% CO_2	14.00
P_g - Stack Pressure, inches of H_2O	-1.00	% O_2	5.20
P_s - Absolute stack pressure, inches Hg	29.08	% N_2	80.80
t_s - Average stack temperature, °F	328.9	Md - dry basis lb/lb mole	30.45
Shape of Duct: (C or R)	C	Ms - wet basis lb/lb mole	29.18
Stack Diameter, Feet	9	Wet Bulb Temp(t'):	135.000
		Dry Bulb Temp(t'):	330.000
		Bws - Moisture content fraction	**0.102**
Cross Sectional Area of Stack, Ft^2	63.62	Moisture determined by wb/db (Y or N)	Y

Method 2 Results

Average DP	0.2031	Q - ACFM	118,220
Average Sqrt DP	0.4473	Qsd - DSCFM	69,046
Average Velocity Vs (ft/sec)	30.972	Qs - SCFM	76,889
		Qs - SCFH	4,613,327

Stack Liner Material:	S	B for Brick, S for Steel
Default WAF:	0.995	
Calculated WAF:		
Type of WAF Applied:	N	D for Default, C for Calculated, N for None
Actual WAF Applied to all runs:		

Client:	Manitowoc Public Utilities	
Facility:	Manitowoc Generating Station	
Test Location:	Boiler B09 Outlet Duct	
Project #:	M113908	
Test Method:	CTM-027	
Test Engineer:	A. L. Sorce	
Test Technician:	Rod Sollars	
Temp ID:	CM-11	
Meter ID:	CM-11	
Pitot ID:	179-A	
Pitot Tube Coefficient:	0.840	
Probe Length:	10.1	**ft**
Probe Liner Material:	Glass	
Nozzle Diameter:	0.305	**in.**
Nozzle Kit ID Number and Material:	Teflon #5	
Meter Calibration Factor (Y):	1.015	
Meter Orifice Setting (Delta H):	1.579	
Sample Plane:	Horizontal	
Port Length:	15.00	**in.**
Port Size (diameter):	6.00	**in.**
Port Type:	Flange	
Duct Shape:	Circular	
Diameter	9	**ft**
Duct Area:	63.617	**Sq. Ft.**
Upstream Diameters:	>0.5	
Downstream Diameters:	>2.0	
Number of Ports Sampled:	2	
Number of Points per Port:	12	
Minutes per Point:	2.5	
Minutes per Reading:	5.0	
Total Number of Traverse Points:	24	
Test Length:	60	**min.**
Train Type:	Hot Box	
Source Condition:	Normal Load	
# of Runs	3	

Client: **Manitowoc Public Utilities**
Facility: **Manitowoc Generating Station**
Test Location: **Boiler B09 Outlet Duct**
Test Method: **CTM-027**

		Run 1	Run 2	Run 3
Identify Analyte:	Ammonia (NH4)			
Molecular Weight:	18.01			
mg (net) collected:		4.76	3.66	2.6

Run 1-Method CTM-027

Client:	Manitowoc Public Utilities		Date:	9/28/11
Facility:	Manitowoc Generating Station		Start Time:	11:30
Test Location:	Boiler B09 Outlet Duct		End Time:	12:40
Source Condition:	69.2 MW			

DRY GAS METER CONDITIONS			STACK CONDITIONS		
ΔH:	3.38	in. H_2O	Static Pressure	0.20	in. H_2O
Meter Temperature, Tm:	67.5	°F	Flue Pressure (Ps):	29.10	in. Hg. abs.
Sqrt ΔP:	0.870	in. H_2O	Carbon Dioxide:	14.00	%
Stack Temperature, Ts:	341.3	°F	Oxygen:	5.30	%
Meter Volume, Vm:	64.915	ft^3	Nitrogen:	80.70	%
Meter Volume, Vmstd:	64.674	dscf	Gas Weight dry, Md:	30.452	lb/lb mole
Meter Volume, Vwstd:	4.564	wscf	Gas Weight wet, Ms:	29.631	lb/lb mole
Isokinetic Variance:	98.3	%I	Excess Air:	33.115	%
			Gas Velocity, Vs:	60.198	fps
Test Length	60.00	in mins.	Volumetric Flow:	229,778	acfm
Nozzle Diameter	0.305	in inches	Volumetric Flow:	137,574	dscfm
Barometric Pressure	29.09	in Hg	Volumetric Flow:	147,282	scfm
Calculated Fo:	1.11		Fo Validity:	#N/A	

MOISTURE DETERMINATION

Initial Impinger Content:	2054.0	ml	Silica Initial Wt.	796.2
Final Impinger Content:	2130.1	ml	Silica Final Wt.	817.0
Difference:	76.1		Difference:	20.8
Total Water Gain:	96.9		Moisture, Bws:	0.066

Port-Point No.	Clock Time	Velocity Head Δp in. H2O	Orifice ΔH in. H2O	Actual Meter Vol. ft^3	Sqrt. Δp	Stack Temp °F	Meter Temp Inlet °F	Meter Temp Outlet °F	Collected Vol. ft^3	Point Vel ft/sec
A-1	11:30:00	0.82	3.61	14.929	0.906	340	63	62	2.801	62.682
A-2	11:32:30	0.72	3.17	17.730	0.849	340	64	62	2.680	58.735
A-3	11:35:00	0.63	2.77	20.410	0.794	341	66	62	2.450	54.942
A-4	11:37:30	0.40	1.76	22.860	0.632	341	66	62	1.980	43.779
A-5	11:40:00	0.51	2.25	24.840	0.714	341	68	62	2.250	49.433
A-6	11:42:30	0.53	2.33	27.090	0.728	341	69	63	2.260	50.393
A-7	11:45:00	0.86	3.79	29.350	0.927	341	70	63	2.860	64.192
A-8	11:47:30	0.55	2.42	32.210	0.742	342	71	63	2.320	51.335
A-9	11:50:00	1.00	4.40	34.530	1.000	342	71	64	3.080	69.220
A-10	11:52:30	1.00	4.40	37.610	1.000	342	71	64	3.080	69.220
A-11	11:55:00	0.93	4.09	40.690	0.964	342	72	64	2.940	66.754
A-12	11:57:30	1.00	4.40	43.630	1.000	342	72	64	3.241	69.220
	12:00:00			46.871						
B-1	12:10:00	0.68	2.99	46.871	0.825	341	67	65	2.549	57.081
B-2	12:12:30	0.68	2.99	49.420	0.825	341	68	65	2.560	57.081
B-3	12:15:00	0.69	3.04	51.980	0.831	341	69	65	2.610	57.499
B-4	12:17:30	0.67	2.95	54.590	0.819	341	70	65	2.480	56.659
B-5	12:20:00	0.65	2.86	57.070	0.806	341	71	65	2.540	55.807
B-6	12:22:30	0.62	2.73	59.610	0.787	341	72	66	2.450	54.504
B-7	12:25:00	0.70	3.08	62.060	0.837	341	74	66	2.570	57.914
B-8	12:27:30	0.84	3.70	64.630	0.917	341	75	66	2.840	63.441
B-9	12:30:00	1.00	4.40	67.470	1.000	342	75	67	3.130	69.220
B-10	12:32:30	1.10	4.84	70.600	1.049	342	75	67	3.190	72.599
B-11	12:35:00	1.00	4.40	73.790	1.000	342	75	68	3.140	69.220
B-12	12:37:30	0.85	3.75	76.930	0.922	342	76	68	2.914	63.818
	12:40:00			79.844						
Total				64.915			70.4	64.5	64.915	
Average			3.38		0.870	341.3	67.5			

DRAFT 10-25-11

Run 2-Method CTM-027

Client:	**Manitowoc Public Utilities**	**Date:**	**9/28/11**
Facility:	**Manitowoc Generating Station**	**Start Time:**	**13:45**
Location:	**Boiler B09 Outlet Duct**	**End Time:**	**15:00**
Source Condition:	**75.0 MW**		

DRY GAS METER CONDITIONS			STACK CONDITIONS		
ΔH:	3.55	In. H_2O	Static Pressure	0.20	in. H_2O
Meter Temperature, Tm:	68.7	°F	Flue Pressure (Ps):	29.10	in. Hg. abs.
Sqrt ΔP:	0.866	In. H_2O	Carbon Dioxide:	13.80	%
Stack Temperature, Ts:	341.3	°F	Oxygen:	5.50	%
Meter Volume, Vm:	67.124	cf	Nitrogen:	80.7	%
Meter Volume, Vmstd:	66.742	dscf	Gas Weight dry, Md:	30.428	lb/lb mole
Meter Volume, Vwstd:	5.021	wscf	Gas Weight wet, Ms:	29.558	lb/lb mole
Isokinetic Variance:	102.2	%I	Excess Air:	34.800	%
			Gas Velocity, Vs:	60.004	fps
Test Length	60.00	in mins.	Volumetric Flow:	229,037	acfm
Nozzle Diameter	0.305	in inches	Volumetric Flow:	136,536	dscfm
Barometric Pressure	29.09	in Hg	Volumetric Flow:	146,808	scfm
Calculated Fo:	1.12		Fo Validity:	#N/A	

MOISTURE DETERMINATION

Initial Impinger Content:	2041.2	ml	Silica Initial Wt.	811.7
Final Impinger Content:	2131.0	ml	Silica Final Wt.	828.5
Difference:	89.8		Difference:	16.8
Total Water Gain:	106.6		Moisture, Bws:	0.070

Port-Point No.	Clock Time	Velocity Head Δp In. H2O	Orifice ΔH In. H2O	Actual Meter Vol. ft^3	Sqrt. Δp	Stack Temp °F	Meter Temp Inlet °F	Meter Temp Outlet °F	Collected Vol. ft^3	Point Vel ft/sec
A-1	13:45:00	0.70	3.26	80.220	0.837	341	66	65	2.630	57.985
A-2	13:47:30	0.71	3.31	82.850	0.843	341	68	65	2.810	58.398
A-3	13:50:00	0.68	3.17	85.660	0.825	341	69	65	2.640	57.151
A-4	13:52:30	0.68	3.17	88.300	0.825	341	70	65	2.630	57.151
A-5	13:55:00	0.62	2.89	90.930	0.787	341	72	65	2.550	54.571
A-6	13:57:30	0.64	2.98	93.480	0.800	341	73	66	2.590	55.444
A-7	14:00:00	0.70	3.26	96.070	0.837	341	73	66	2.720	57.985
A-8	14:02:30	0.80	3.73	98.790	0.894	341	74	66	2.870	61.989
A-9	14:05:00	0.94	4.38	101.660	0.970	342	74	66	3.190	67.194
A-10	14:07:30	0.98	4.57	104.850	0.990	342	74	67	3.130	68.609
A-11	14:10:00	1.00	4.66	107.980	1.000	342	74	67	3.190	69.305
A-12	14:12:30	1.00	4.66	111.170	1.000	342	74	67	3.322	69.305
	14:15:00			114.492						
B-1	14:30:00	0.75	3.49	114.689	0.866	340	68	66	2.801	60.020
B-2	14:32:30	0.52	2.42	117.490	0.721	340	69	66	2.350	49.977
B-3	14:35:00	0.58	2.70	119.840	0.762	341	70	66	2.470	52.781
B-4	14:37:30	0.50	2.33	122.310	0.707	341	71	66	2.270	49.006
B-5	14:40:00	0.40	1.86	124.580	0.632	341	71	66	2.090	43.833
B-6	14:42:30	0.50	2.33	126.670	0.707	341	72	66	2.250	49.006
B-7	14:45:00	0.81	3.77	128.920	0.900	342	72	66	2.920	62.375
B-8	14:47:30	0.96	4.47	131.840	0.980	342	73	66	3.050	67.905
B-9	14:50:00	0.88	4.10	134.890	0.938	342	72	66	3.120	65.014
B-10	14:52:30	1.00	4.66	138.010	1.000	342	72	66	3.240	69.305
B-11	14:55:00	1.00	4.66	141.250	1.000	342	72	66	3.210	69.305
B-12	14:57:30	0.92	4.29	144.460	0.959	341	73	67	3.081	66.475
	15:00:00			147.541						
Total				67.124			71.5	66.0	67.124	
Average			3.55		0.866	341.3	68.7			

Run 3-Method CTM-027

Client: Manitowoc Public Utilities
Facility: Manitowoc Generating Station
Location: Boiler B09 Outlet Duct
Source Condition: 72.0 MW

Date: 9/28/11
Start Time: 15:30
End Time: 16:35

DRY GAS METER CONDITIONS		
ΔH:	3.49	In. H_2O
Meter Temperature, Tm:	72.3	°F
Sqrt ΔP:	0.862	In. H_2O
Stack Temperature, Ts:	342.3	°F
Meter Volume, Vm:	66.204	cf
Meter Volume, Vmstd:	65.382	dscf
Meter Volume, Vwstd:	4.865	wscf
Isokinetic Variance:	100.7	%I
Test Length	60.00	in mins.
Nozzle Diameter	0.305	in inches
Barometric Pressure	29.09	in Hg
Calculated Fo:	1.11	

STACK CONDITIONS		
Static Pressure	0.20	in. H_2O
Flue Pressure (Ps):	29.10	in. Hg. abs.
Carbon Dioxide:	14.10	%
Oxygen:	5.20	%
Nitrogen:	80.7	%
Gas Weight dry, Md:	30.464	lb/lb mole
Gas Weight wet, Ms:	29.601	lb/lb mole
Excess Air:	32.289	%
Gas Velocity, Vs:	59.723	fps
Volumetric Flow:	227,963	acfm
Volumetric Flow:	135,823	dscfm
Volumetric Flow:	145,930	scfm
Fo Validity:	#N/A	

MOISTURE DETERMINATION

Initial Impinger Content:	2164.5	ml	Silica Initial Wt.	796.6	
Final Impinger Content:	2253.5	ml	Silica Final Wt.	810.9	
Difference:	89.0		Difference:	14.3	
Total Water Gain:	103.3		Moisture, Bws:	0.069	

Port-Point No.	Clock Time	Velocity Head Δp In. H2O	Orifice ΔH in. H2O	Actual Meter Vol. ft^3	Sqrt. Δp	Stack Temp °F	Meter Temp Inlet °F	Meter Temp Outlet °F	Collected Vol. ft^3	Point Vel ft/sec
A-1	15:30:00	0.70	3.23	47.769	0.837	341	67	66	2.651	57.981
A-2	15:32:30	0.58	2.68	50.420	0.762	341	71	66	2.410	52.778
A-3	15:35:00	0.54	2.49	52.830	0.735	342	72	66	2.420	50.926
A-4	15:37:30	0.52	2.40	55.250	0.721	342	73	66	2.300	49.974
A-5	15:40:00	0.52	2.40	57.550	0.721	342	74	67	2.280	49.974
A-6	15:42:30	0.54	2.49	59.830	0.737	342	75	67	2.380	51.067
A-7	15:45:00	0.79	3.65	62.210	0.889	342	75	67	2.830	61.596
A-8	15:47:30	0.75	3.46	65.040	0.866	343	76	68	2.770	60.016
A-9	15:50:00	1.00	4.62	67.810	1.000	343	76	68	3.190	69.301
A-10	15:52:30	1.00	4.62	71.000	1.000	343	77	69	3.180	69.301
A-11	15:55:00	1.10	5.08	74.180	1.049	343	77	69	3.370	72.683
A-12	15:57:30	1.00	4.62	77.550	1.000	343	77	69	3.232	69.301
	16:00:00			80.782						
B-1	16:05:00	0.58	2.68	80.782	0.762	342	74	70	2.448	52.778
B-2	16:07:30	0.60	2.77	83.230	0.775	342	75	70	2.480	53.680
B-3	16:10:00	0.60	2.77	85.710	0.775	342	75	70	2.510	53.680
B-4	16:12:30	0.64	2.95	88.220	0.800	342	76	70	2.560	55.441
B-5	16:15:00	0.64	2.95	90.780	0.800	342	77	70	2.550	55.441
B-6	16:17:30	0.60	2.77	93.330	0.775	342	78	70	2.470	53.680
B-7	16:20:00	0.65	3.00	95.800	0.806	342	78	70	2.590	55.872
B-8	16:22:30	0.77	3.55	98.390	0.877	343	78	71	2.820	60.811
B-9	16:25:00	0.92	4.25	101.210	0.959	343	78	71	3.040	66.471
B-10	16:27:30	0.98	4.52	104.250	0.990	343	78	71	3.170	68.604
B-11	16:30:00	1.00	4.62	107.420	1.000	343	79	71	3.160	69.301
B-12	16:32:30	1.10	5.08	110.580	1.049	343	79	71	3.393	72.683
	16:35:00			113.973						
Total				66.204			75.6	68.9	66.204	
Average			3.49		0.862	342.3	72.3			

CONTROLLED CONDENSATE TEST RESULTS

Date:	9/29/2011	Condition:	High Load
Project:	M113908	Data Taken By:	A. L. Sorce
Location:	Manitowoc Public Utilities		
Source:	Boiler B09 Outlet Duct		

Test 1:		Time:		08:40 - 09:40
Pressure, Barometric(Hg"):.....................	29.05			
Pressure, Static(H_2O"):..........................	0.20	Water Vapor in Flue Gas (Bws):.............................		0.082
Pressure, Stack(Hg"):.............................	29.065			
Initial Volume (cu.ft.)...............................	6.69	Flue Gas % CO2	14.00	
Final Volume (cu.ft.)................................	13.834	Flue Gas % O2	5.20	
Meter Temperature (°F)..........................	66.08	lbs fuel/hr	48933	
Meter Volume (dscf)................................	7.067	tons fuel/hr	24.4665	
Meter Calibration (Y)...............................	1.015	btu/lb	14181	
Initial Wt. (grms or mls)...........................	421.9	Heat Input MMBtu/hr	693.918873	
Final Wt. (grms or mls)............................	435.2	Fd based fuel factor	8845.32	
Average Delta H (ΔH).............................	0.030			

Test 2:		Time:		10:40 - 11:40
Pressure, Barometric(Hg"):.....................	29.05			
Pressure, Static(H_2O"):..........................	0.20	Water Vapor in Flue Gas (Bws):.............................		0.078
Pressure, Stack(Hg"):.............................	29.065			
Initial Volume (cu.ft.)...............................	4.308	Flue Gas % CO2	13.70	
Final Volume (cu.ft.)................................	10.351	Flue Gas % O2	5.50	
Meter Temperature (°F)..........................	71.40	lbs fuel/hr	49948	
Meter Volume (dscf)................................	5.918	tons fuel/hr	24.974	
Meter Calibration (Y)...............................	1.015	btu/lb	14181	
Initial Wt. (grms or mls)...........................	424.0	Heat Input MMBtu/hr	708.312588	
Final Wt. (grms or mls)............................	434.6	Fd based fuel factor	8845.32	
Average Delta H (ΔH).............................	0.030			

Test 3:		Time:		12:25 - 13:25
Pressure, Barometric(Hg"):.....................	29.05			
Pressure, Static(H_2O"):..........................	0.20	Water Vapor in Flue Gas (Bws):.............................		0.079
Pressure, Stack(Hg"):.............................	29.065			
Initial Volume (cu.ft.)...............................	1.331	Flue Gas % CO2	14.20	
Final Volume (cu.ft.)................................	7.399	Flue Gas % O2	5.00	
Meter Temperature (°F)..........................	70.00	lbs fuel/hr	48985	
Meter Volume (dscf)................................	5.958	tons fuel/hr	24.4925	
Meter Calibration (Y)...............................	1.015	btu/lb	14181	
Initial Wt. (grms or mls)...........................	408.5	Heat Input MMBtu/hr	694.656285	
Final Wt. (grms or mls)............................	419.3	Fd based fuel factor	8845.32	
Average Delta H (ΔH).............................	0.030			

METHOD 2 VOLUMETRIC FLOW DATA

Project Number	M113908	**Operating Level:**	High Load
Client:	Manitowoc Public Utilities	**Run No.:**	Pre 1
Plant:	Manitowoc, WI	**Date:**	9/29/2011
Location:	Boiler B09 Outlet Duct	**Start Time:**	8:21
Pitot ID:	182-B	**End Time:**	8:34
Pitot Coefficient:	0.840	**RM Testers:**	ALS/rods
Probe Length:	12.0'	**Port Length:**	11.0"

Port	Point	DP (in. H_2O)	Sqrt. DP	Temp (°F)	Velocity (V)	Port	Point	DP (in. H_2O)	Sqrt. DP	Temp (°F)	Velocity (V)
A	1	0.54	0.735	330.0	50.706	B	1	0.18	0.424	338.0	29.423
A	2	0.58	0.762	333.0	52.650	B	2	0.64	0.800	338.0	55.480
A	3	0.60	0.775	337.0	53.685	B	3	0.72	0.849	339.0	58.882
A	4	0.61	0.781	338.0	54.164	B	4	0.69	0.831	339.0	57.642
A	5	0.62	0.787	339.0	54.640	B	5	0.68	0.825	339.0	57.223
A	6	0.61	0.781	340.0	54.232	B	6	0.64	0.800	340.0	55.549
A	7	0.61	0.781	340.0	54.232	B	7	0.63	0.794	340.0	55.114
A	8	0.62	0.787	340.0	54.675	B	8	0.76	0.872	340.0	60.534
A	9	0.63	0.794	340.0	55.114	B	9	0.81	0.900	340.0	62.493
A	10	0.89	0.943	340.0	65.507	B	10	0.90	0.949	340.0	65.874
A	11	0.84	0.917	338.0	63.560	B	11	0.98	0.990	340.0	68.739
A	12	0.83	0.911	337.0	63.141	B	12	0.98	0.990	340.0	68.739

Test Parameters

P_{bar} - Barometric pressure, inches Hg	29.05	% CO_2	14.00
P_g - Stack Pressure, inches of H_2O	0.20	% O_2	5.20
P_s - Absolute stack pressure, inches Hg	29.06	% N_2	80.80
t_s - Average stack temperature, °F	338.5	Md - dry basis lb/lb mole	30.45
Shape of Duct: (C or R)	C	Ms - wet basis lb/lb mole	29.44
Stack Diameter, Feet	9		
		Bws - Moisture content fraction	**0.081**
Cross Sectional Area of Stack, Ft^2	63.62	Moisture determined by wb/db (Y or N)	N

Method 2 Results

Average DP	0.6913	Q - ACFM	218,193
Average Sqrt DP	0.8240	Qsd - DSCFM	128,795
Average Velocity Vs (ft/sec)	57.163	Qs - SCFM	140,146
		Qs - SCFH	8,408,786

METHOD 2 VOLUMETRIC FLOW DATA

Project Number	M113908	**Operating Level:**	High Load
Company:	Manitowoc Public Utilities	**Run No.:**	Post 1/Pre 2
Plant:	Manitowoc, WI	**Date:**	9/29/11
Location:	Boiler B09 Outlet Duct	**Start Time:**	9:53
Pitot ID:	182-B	**End Time:**	10:03
Pitot Coefficient:	0.840	**RM Testers:**	ALS/rods
Probe Length:	12.0'	**Port Length:**	11.0"

Port	Point	DP (in. H_2O)	Sqrt. DP	Temp (°F)	Velocity (V)	Port	Point	DP (in. H_2O)	Sqrt. DP	Temp (°F)	Velocity (V)
A	1	0.56	0.748	341.0	52.009	B	1	0.57	0.755	341.0	52.471
A	2	0.60	0.775	341.0	53.834	B	2	0.56	0.748	341.0	52.009
A	3	0.63	0.794	341.0	55.164	B	3	0.50	0.707	341.0	49.144
A	4	0.60	0.775	341.0	53.834	B	4	0.48	0.693	341.0	48.151
A	5	0.57	0.755	341.0	52.471	B	5	0.47	0.686	341.0	47.647
A	6	0.55	0.742	341.0	51.542	B	6	0.50	0.707	341.0	49.144
A	7	0.56	0.748	341.0	52.009	B	7	0.77	0.877	342.0	61.024
A	8	0.63	0.794	341.0	55.164	B	8	0.88	0.938	342.0	65.237
A	9	0.68	0.825	341.0	57.311	B	9	1.00	1.000	342.0	69.543
A	10	0.84	0.917	341.0	63.698	B	10	1.10	1.049	342.0	72.937
A	11	0.89	0.943	341.0	65.566	B	11	1.00	1.000	342.0	69.543
A	12	0.83	0.911	340.0	63.278	B	12	1.00	1.000	342.0	69.543

Test Parameters

P_{bar} - Barometric pressure, inches Hg	29.05	% CO_2	13.85
P_g - Stack Pressure, inches of H_2O	0.20	% O_2	5.35
P_s - Absolute stack pressure, inches Hg	29.06	% N_2	80.80
t_s - Average stack temperature, °F	341.2	Md - dry basis lb/lb mole	30.43
Shape of Duct: (C or R)	C	Ms - wet basis lb/lb mole	29.42
Stack Diameter, Feet	9		
	0		
	0	**Bws - Moisture content fraction**	**0.081**
Cross Sectional Area of Stack, Ft^2	63.62	Moisture determined by wb/db (Y or N)	N

Method 2 Results

Average DP	0.6988	Q - ACFM	219,835
Average Sqrt DP	0.8286	Qsd - DSCFM	129,332
Average Velocity Vs (ft/sec)	57.593	Qs - SCFM	140,731
		Qs - SCFH	8,443,869

129064 DSCFM

METHOD 2 VOLUMETRIC FLOW DATA

Project Number	M113908	**Operating Level:**	High Load
Company:	Manitowoc Public Utilities	**Run No.:**	Post 2/Pre 3
Plant:	Manitowoc, WI	**Date:**	9/29/11
Location:	Boiler B09 Outlet Duct	**Start Time:**	11:45
Pitot ID:	182-B	**End Time:**	11:56
Pitot Coefficient:	0.840	**RM Testers:**	ALS/rods
Probe Length:	12.0'	**Port Length:**	11.0"

Port	Point	DP (in. H_2O)	Sqrt. DP	Temp (^oF)	Velocity (V)	Port	Point	DP (in. H_2O)	Sqrt. DP	Temp (^oF)	Velocity (V)
A	1	0.72	0.849	342.0	58.961	B	1	0.55	0.742	341.0	51.500
A	2	0.65	0.806	344.0	56.091	B	2	0.63	0.794	341.0	55.118
A	3	0.57	0.755	344.0	52.526	B	3	0.64	0.800	341.0	55.554
A	4	0.50	0.707	344.0	49.195	B	4	0.60	0.775	341.0	53.790
A	5	0.52	0.721	344.0	50.170	B	5	0.57	0.755	341.0	52.428
A	6	0.54	0.735	344.0	51.125	B	6	0.56	0.748	341.0	51.966
A	7	0.68	0.825	344.0	57.371	B	7	0.58	0.762	342.0	52.919
A	8	0.81	0.900	344.0	62.615	B	8	0.61	0.781	343.0	54.304
A	9	0.90	0.949	344.0	66.002	B	9	0.63	0.794	343.0	55.187
A	10	0.98	0.990	344.0	68.873	B	10	0.68	0.825	343.0	57.335
A	11	1.20	1.095	344.0	76.213	B	11	0.71	0.843	343.0	58.586
A	12	1.10	1.049	343.0	72.923	B	12	0.74	0.860	343.0	59.811

Test Parameters

P_{bar} - Barometric pressure, inches Hg	29.05	% CO_2	13.95	
P_g - Stack Pressure, inches of H_2O	0.20	% O_2	5.25	
P_s - Absolute stack pressure, inches Hg	29.06	% N_2	80.80	
t_s - Average stack temperature, ^oF	342.8	Md - dry basis lb/lb mole	30.44	
Shape of Duct: (C or R)	C	Ms - wet basis lb/lb mole	29.47	
Stack Diameter, Feet	9			
	0			
	0	**Bws - Moisture content fraction**		**0.078**
Cross Sectional Area of Stack, Ft^2	63.62	Moisture determined by wb/db (Y or N)		N

Method 2 Results

Average DP	0.6946	Q - ACFM	219,563
Average Sqrt DP	0.8274	Qsd - DSCFM	129,331
Average Velocity Vs (ft/sec)	57.522	Qs - SCFM	140,272
		Qs - SCFH	8,416,347

129 332
DSCFM

METHOD 2 VOLUMETRIC FLOW DATA

Project Number	M113908	**Operating Level:**	High Load
Company:	Manitowoc Public Utilities	**Run No.:**	Post 3
Plant:	Manitowoc, WI	**Date:**	9/29/11
Location:	Boiler B09 Outlet Duct	**Start Time:**	13:43
Pitot ID:	182-B	**End Time:**	13:54
Pitot Coefficient:	0.840	**RM Testers:**	ALS/rods
Probe Length:	12.0'	**Port Length:**	11.0"

Port	Point	DP (in. H_2O)	Sqrt. DP	Temp (°F)	Velocity (V)	Port	Point	DP (in. H_2O)	Sqrt. DP	Temp (°F)	Velocity (V)
A	1	0.55	0.742	342.0	51.519	B	1	0.46	0.678	344.0	47.174
A	2	0.59	0.768	342.0	53.359	B	2	0.53	0.728	344.0	50.637
A	3	0.66	0.812	342.0	56.436	B	3	0.52	0.721	344.0	50.157
A	4	0.64	0.800	342.0	55.575	B	4	0.53	0.728	344.0	50.637
A	5	0.60	0.775	342.0	53.810	B	5	0.55	0.742	344.0	51.583
A	6	0.61	0.781	342.0	54.256	B	6	0.63	0.794	344.0	55.207
A	7	0.59	0.768	343.0	53.393	B	7	0.79	0.889	344.0	61.822
A	8	0.58	0.762	343.0	52.938	B	8	0.89	0.943	344.0	65.618
A	9	0.66	0.812	344.0	56.507	B	9	0.92	0.959	344.0	66.715
A	10	0.79	0.889	344.0	61.822	B	10	0.76	0.872	344.0	60.636
A	11	0.95	0.975	344.0	67.794	B	11	1.00	1.000	344.0	69.555
A	12	1.00	1.000	343.0	69.511	B	12	1.00	1.000	344.0	69.555

Test Parameters

P_{bar} - Barometric pressure, inches Hg	29.05	% CO_2	14.20	
P_g - Stack Pressure, inches of H_2O	0.20	% O_2	5.00	
P_s - Absolute stack pressure, inches Hg	29.06	% N_2	80.80	
t_s - Average stack temperature, °F	343.4	Md - dry basis lb/lb mole	30.47	
Shape of Duct: (C or R)	C	Ms - wet basis lb/lb mole	29.49	
Stack Diameter, Feet	9			
	0			
	0	**Bws - Moisture content fraction**		**0.079**
Cross Sectional Area of Stack, Ft^2	63.62	Moisture determined by wb/db (Y or N)		N

Method 2 Results

Average DP	0.7000	Q - ACFM	220,464
Average Sqrt DP	0.8307	Qsd - DSCFM	129,633
Average Velocity Vs (ft/sec)	57.758	Qs - SCFM	140,753
		Qs - SCFH	8,445,172

129 482
DSCFm

METHOD 4 MOISTURE DETERMINATION

Project Number:	M113908	**Run Number:**	1	
Client:	Manitowoc Public Utilities	**Condition:**	High Load	
Plant:	Manitowoc, WI	**Time:**	**Start-** 8:40	**End-** 9:40
Location:	Boiler B09 Outlet Duct	**Data Taken By:**	ALS	

Pressure, Barometric(Hg"):	29.05	**Meter Calibration (Y):**	1.015
Delta H:	0.030	**Meter Delta H (dH):**	1.579
Meter Initial Volume:	6.690	**Initial Wt:**	221.9
Meter Final Volume:	13.834	**Final Wt:**	225.2
Meter Temperature:	66.08	**Initial Volume:**	200.0
Meter Volume dscf:	7.067	**Final Volume:**	210.0
		Water Vapor in Flue Gas (Bws):	**0.081**

Project Number:	M113908	**Run Number:**	2	
Client:	Manitowoc Public Utilities	**Condition:**	High Load	
Plant:	Manitowoc, WI	**Time:**	**Start-** 10:40	**End-** 11:40
Location:	Boiler B09 Outlet Duct	**Data Taken By:**	ALS	

Pressure, Barometric(Hg"):	29.05	**Meter Calibration (Y):**	1.015
Delta H:	0.030	**Meter Delta H (dH):**	1.579
Meter Initial Volume:	4.308	**Initial Wt:**	224.0
Meter Final Volume:	10.351	**Final Wt:**	226.6
Meter Temperature:	71.40	**Initial Volume:**	200.0
Meter Volume dscf:	5.918	**Final Volume:**	208.0
		Water Vapor in Flue Gas (Bws):	**0.078**

Project Number:	M113908	**Run Number:**	3	
Client:	Manitowoc Public Utilities	**Condition:**	High Load	
Plant:	Manitowoc, WI	**Time:**	**Start-** 12:25	**End-** 13:25
Location:	Boiler B09 Outlet Duct	**Data Taken By:**	ALS	

Pressure, Barometric(Hg"):	29.05	**Meter Calibration (Y):**	1.015
Delta H:	0.030	**Meter Delta H (dH):**	1.579
Meter Initial Volume:	1.331	**Initial Wt:**	208.5
Meter Final Volume:	7.399	**Final Wt:**	211.3
Meter Temperature:	70.00	**Initial Volume:**	200.0
Meter Volume dscf:	5.958	**Final Volume:**	208.0
		Water Vapor in Flue Gas (Bws):	**0.079**

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Procedures for Calibration

Nozzles

The nozzles are measured according to Method 5, Section 5.1

Dry Gas Meters

The test meters are calibrated according to Method 5, Section 5.3 and "Procedures for Calibrating and Using Dry Gas Volume Meters as Calibration Standards" by P.R. Westlin and R.T. Shigehara, March 10, 1978.

Analytical Balance

The accuracy of the analytical balance is checked with Class S, Stainless Steel Type 303 weights manufactured by F. Hopken and Son, Jersey City, New Jersey.

Temperature Sensing Devices

The potentiometer and thermocouples are calibrated utilizing a NBS traceable millivolt source.

Pitot Tubes

The pitot tubes utilized during this test program are manufactured according to the specification described and illustrated in the *Code of Federal Regulations*, Title 40, Part 60, Appendix A, Methods 1 and 2. The pitot tubes comply with the alignment specifications in Method 2, Section 4; and the pitot tube assemblies are in compliance with specifications in the same section.

Client: Manitowoc Public Utilities
Facility: Manitowoc Generating Station
Project #: M113908

Test Location: Boiler B09 Outlet Duct
Date: 9/28/11
Operator: A. L. Sorce

Calibration Gases

Type	Setting	Cylinder ID	Cylinder Value	Analyzer Response	Difference, % of Span	Expiration Date	Final Bottle Pressure, PSI	Mid cylinder % of high cylinder
CO2%	Zero		0	0.00	0.00%			
	Mid	CC122847	11.97	12.00	-0.15%	4/5/2014		61.42%
	High	CC20740	19.49	19.50	-0.05%	9/8/2012		
O2%	Zero		0	0.00	0.00%			
	Mid	CC122847	9.98	10.00	-0.09%	4/5/2014		45.22%
	High	SG9168042BAL	22.07	22.15	-0.36%	3/2/2014		

Analyzer Data

Type	Model/Serial #
CO2 %	01440D1/3791
O2 %	01440D1/3791

CO2 % Correction Data

Run #	Cma	Precal	Postcal	Pre zero	Post zero	Co	Cm	C	Cgas	Span Bias	Span Drift	Zero Bias	Zero Drift
1	11.97	12.00	12.10	0.10	0.10	0.10	12.05	14.10	14.0	-0.51	0.51	-0.51	0.00
2	11.97	12.10	12.10	0.10	0.10	0.10	12.10	13.90	13.8	-0.51	0.00	-0.51	0.00
3	11.97	12.10	12.10	0.10	0.10	0.10	12.10	14.20	14.1	-0.51	0.00	-0.51	0.00

O2 % Correction Data

Run #	Cma	Precal	Postcal	Pre zero	Post zero	Co	Cm	C	Cgas	Span Bias	Span Drift	Zero Bias	Zero Drift
1	9.98	10.00	10.20	0.10	0.10	0.10	10.10	5.40	5.3	-0.91	1.03	-0.51	0.00
2	9.98	10.20	10.20	0.10	0.10	0.10	10.20	5.70	5.5	-0.91	0.00	-0.51	0.00
3	9.98	10.20	10.20	0.10	0.10	0.10	10.20	5.40	5.2	-0.91	0.00	-0.51	0.00

Airgas

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http://www.airgas.com

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Part Number:	E03NI78E15A1066	Reference Number:	54-124259698-3
Cylinder Number:	CC122847	Cylinder Volume:	151 Cu.Ft.
Laboratory:	ASG - Chicago - IL	Cylinder Pressure:	2015 PSIG
Analysis Date:	Apr 05, 2011	Valve Outlet:	590

Expiration Date: Apr 05, 2014

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
CARBON DIOXIDE	10.00 %	9.989 %	G1	+/- 1% NIST Traceable
OXYGEN	12.00 %	11.97 %	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM/O2	06120209	CC195591	20.9% OXYGEN/NITROGEN	Dec 01, 2015
NTRM/CO2	97051012	SG9112972BAL	10.818% CARBON DIOXIDE/NITROGEN	May 15, 2012

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
(CO2-1)HORIBA VIA-510	NDIR	Apr 03, 2011
(O2-1)HORIBA MPA-510	Paramagnetic	Mar 10, 2011

Triad Data Available Upon Request

Notes:

Approved for Release

Airgas

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Airgas Specialty Gases
12722 S. Wentworth Avenue
Chicago, IL 60628
1-773-785-3000
FAX: 1-773-785-1928
www.airgas.com

Part Number:	E02NI80E15ACMD7	Reference Number:	54-124190567-1
Cylinder Number:	CC20740	Cylinder Volume:	156 Cu.Ft.
Laboratory:	ASG - Chicago - IL	Cylinder Pressure:	2015 PSIG
Analysis Date:	Sep 08, 2009	Valve Outlet:	580

Expiration Date: Sep 08, 2012

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
CARBON DIOXIDE	19.50 %	19.49 %	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM/CO2	40604	XC034327B	19.84% CARBON DIOXIDE/	May 15, 2012

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
HORIBA 510	NDIR	Aug 21, 2009

Triad Data Available Upon Request

Notes:

QA Approval

Airgas

CERTIFICATE OF ANALYSIS
Grade of Product: EPA Protocol

Airgas Specialty Gases
12722 S. Wentworth Avenue
Chicago, IL 60628
(773) 785-3000 Ext. 13 Fax: (773) 78
http://www.airgas.com

Part Number:	E02NI78E15A0124	Reference Number:	54-124255256-7
Cylinder Number:	SG9168042BAL	Cylinder Volume:	146 Cu.Ft.
Laboratory:	ASG - Chicago - IL	Cylinder Pressure:	2015 PSIG
Analysis Date:	Mar 02, 2011	Valve Outlet:	590

Expiration Date: Mar 02, 2014

Certification performed in accordance with "EPA Traceability Protocol (Sept. 1997)" using the assay procedures listed. Analytical Methodology does not require correction for analytical interferences. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.
Do Not Use This Cylinder below 150 psig.i.e. 1 Mega Pascal

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty
OXYGEN	22.00 %	22.06 %	G1	+/- 1% NIST Traceable
NITROGEN	Balance			

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Expiration Date
NTRM/O2	06060810	CC206131	22.51% OXYGEN/NITROGEN	May 01, 2016

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
(O2-1)HORIBA MPA-510	Paramagnetic	Feb 10, 2011

Triad Data Available Upon Request

Notes:

Approved for Release

Meter Box Calibration

Dry Gas Meter No.	CM11	Date:	September 12, 2011
Standard Meter No.	16541852	Calibrated By:	RichS
Standard Meter (Y)	1.0005	Barometric Pressure:	29.47

Run Number		Orifice Setting in H_2O Chg (H)	Standard Meter Gas Volume vr	Dry Gas Meter Gas Volume vd	Standard Meter Temp. F° tr	Dry Gas Meter Inlet Temp. F° tdi	Dry Gas Meter Outlet Temp. F° tdo	Dry Gas Meter Avg. Temp. F° td	Time Min	Time Sec	Y	Chg (H)
Final			76.320	74.727	70	73	72					
Initial			71.261	69.719	69	72	71					
Difference	1	0.20	5.059	5.008	70	73	72	72	18	39	1.014	1.540
Final			81.409	79.740	69	73	72					
Initial			76.320	74.727	70	73	72					
Difference	2	0.50	5.089	5.013	70	73	72	73	11	40	1.020	1.487
Final			87.626	85.889	69	74	72					
Initial			81.409	79.740	69	73	72					
Difference	3	0.70	6.217	6.149	69	74	72	73	12	19	1.016	1.551
Final			108.545	106.584	71	76	74					
Initial			101.075	99.194	70	74	73					
Difference	4	0.90	7.470	7.390	71	75	74	74	13	0	1.016	1.544
Final			115.632	113.570	71	76	74					
Initial			108.790	106.721	70	74	73					
Difference	5	1.20	6.842	6.849	71	75	74	74	10	30	1.003	1.600
Final			71.060	69.544	69	73	71					
Initial			65.950	64.538	69	70	70					
Difference	6	2.00	5.110	5.006	69	72	71	71	6	21	1.020	1.750
									Average		**1.015**	**1.579**

Stack Temperature Sensor Calibration

Meter Box # : *CM11*

Name : *RichS*

Ambient Temperature : *81* *°F*

Date : *September 12, 2011*

Calibrator Model # : *CL23A*

Serial # : *T-249465*

Date Of Certification : *September 22, 2006*

Primary Standards Directly Traceable National Institute of Standards and Technology (NIST)

Reference Source Temperature (° F)	Test Thermometer Temperature (° F)	Temperature Difference %
0	-2	0.4
250	247	0.4
600	596	0.4
1200	1198	0.1

$$\frac{(\text{Ref. Temp., °F} + 460) - (\text{Test Therm. Temp., °F} + 460)}{\text{Ref. Temp., °F} + 460} * 100 <= 1.5\ \%$$

Meter Box Calibration

Dry Gas Meter No.	CM11	Date:	October 12, 2011
Standard Meter No.	16541852	Calibrated By:	BRS
Standard Meter (Y)	1.0005	Barometric Pressure:	29.47

Run Number		Orifice Setting in H_2O Chg (H)	Standard Meter Gas Volume vr	Dry Gas Meter Gas Volume vd	Standard Meter Temp. F° tr	Dry Gas Meter Inlet Temp. F° tdi	Dry Gas Meter Outlet Temp. F° tdo	Dry Gas Meter Avg. Temp. F° td	Time Min	Time Sec	Y	Chg (H)
Final			34.990	13.960	66	69	68					
Initial			29.535	8.465	66	68	68					
Difference	1	0.20	5.455	5.495	66	69	68	68	19	0	0.996	1.366
Final			40.957	19.965	66	70	69					
Initial			35.249	14.218	66	69	69					
Difference	2	0.50	5.708	5.747	66	70	69	69	13	19	0.998	1.529
Final			47.255	26.265	66	70	69					
Initial			41.660	20.647	66	70	69					
Difference	3	0.70	5.595	5.618	66	70	69	70	10	59	1.001	1.515
Final			53.644	32.680	66	70	69					
Initial			47.752	26.760	66	70	70					
Difference	4	0.90	5.892	5.920	66	70	70	70	10	6	1.000	1.485
Final			61.054	40.121	66	70	69					
Initial			54.122	33.153	66	70	70					
Difference	5	1.20	6.932	6.968	66	70	70	70	10	44	0.999	1.615
Final			29.309	8.245	66	68	68					
Initial			23.823	2.770	66	67	67					
Difference	6	2.00	5.486	5.475	66	68	68	68	6	48	1.000	1.733

Average	**0.999**	**1.541**

Stack Temperature Sensor Calibration

Meter Box # : *CM11* *Name :* *BRS*

Ambient Temperature : *81* *° F* *Date :* *October 12, 2011*

Calibrator Model # : *CL23A*

Serial # : *T-249465*

Date Of Certification : *September 22, 2006*

Primary Standards Directly Traceable National Institute of Standards and Technology (NIST)

Reference Source Temperature (° F)	Test Thermometer Temperature (° F)	Temperature Difference %
0	-2	0.4
250	247	0.4
600	596	0.4
1200	1198	0.1

$$\frac{(\text{Ref. Temp., °F} + 460) - (\text{Test Therm. Temp., °F} + 460)}{\text{Ref. Temp., °F} + 460} * 100 <= 1.5\ \%$$

Platt Environmental Services, Inc.

1520 Kensington Road, Suite 204
Oak Brook, IL 60523-2141
630-521-9400
630-521-9494 fax

Nozzle Calibration Sheet
Teflon Set #5

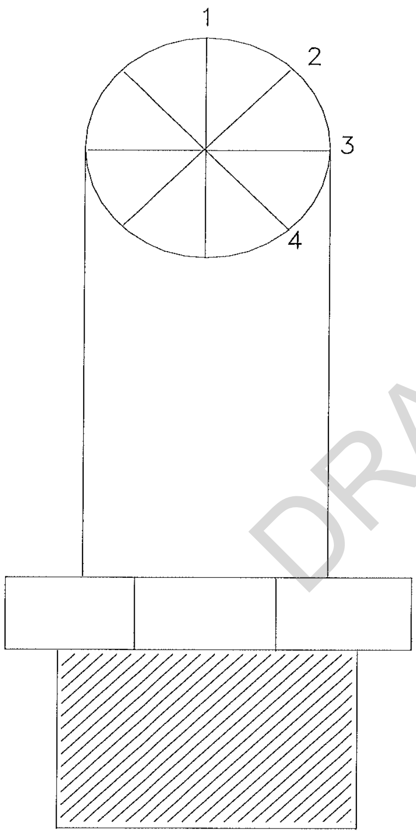
Nominal Diameter	.120	.175	.200	.230	.250	.275	.300	.310	.375	.500	Other
Nozzle Diameter	.122	.179	.208	.231	.266	.276	.305	.313	.361	.475	
Nozzle Identification Number	4		7	8	#9	9	10	12		#16	

Nozzle Calibration

Date: 8/23/2011

Nozzle ID No.: T-40

Analyst: SD



0.305 1

0.305 2

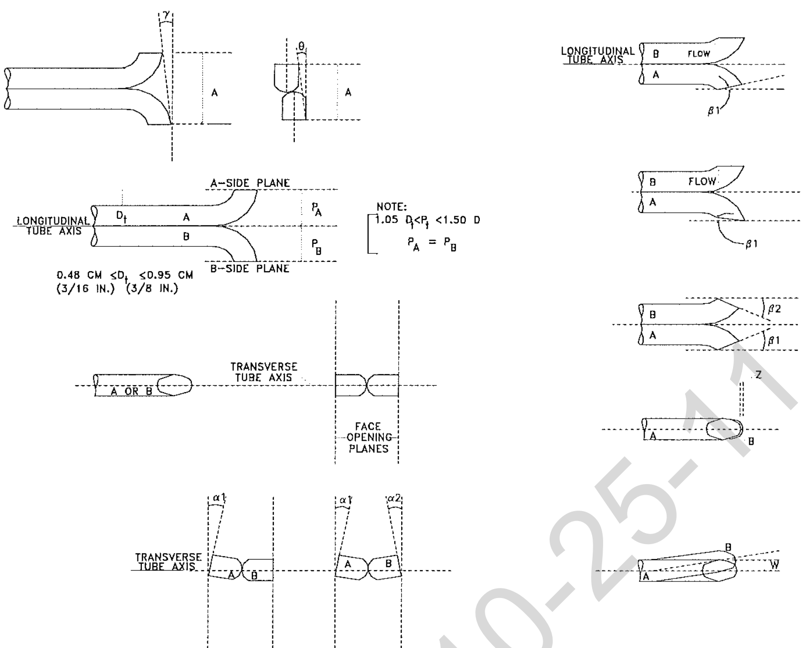
0.305 3

0.305 4

Average
0.305

S TYPE PITOT TUBE INSPECTION FORM

Pitot Tube No: 176 Date: 9/8/2011 Inspectors Name: BWH



Pitot tube assembly level? x yes ____ no

Pitot tube openings damaged? ____ yes (explain below) x no

a_1 = 3 ° (<10°), a_2 = 3 ° (<10°) z = A sin g = 0.039 (in.); (<0.125 in.)

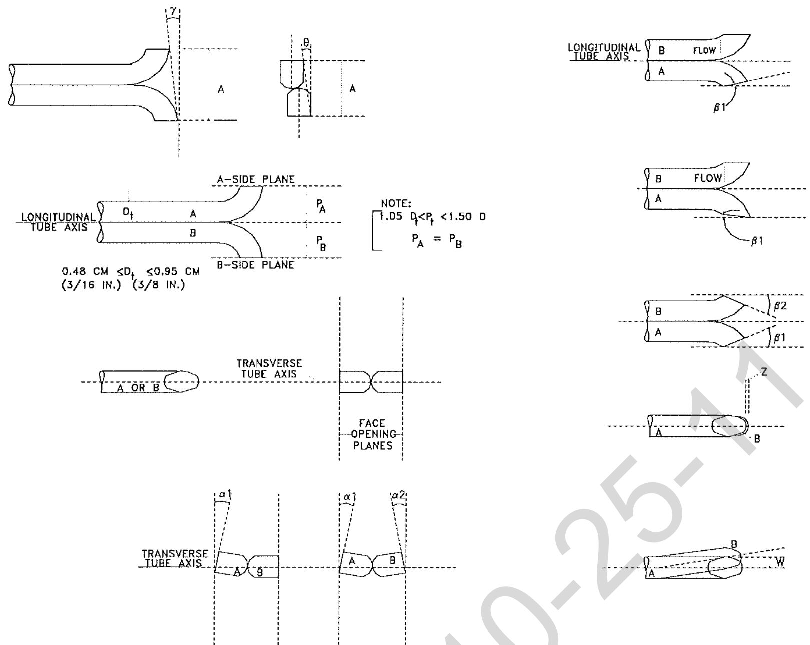
b_1 = 0 ° (<5°), b_2 = 3 ° (<5°) w = A sin q = 0.000 (in.); (<0.03125 in.)

γ = 2 °, θ = 0 °, A = 1.120 (in.) P_A = 0.560 (in.), P_B = 0.560 (in.), D_t = 0.375 (in.)

Calibration required? ____ yes x no

S TYPE PITOT TUBE INSPECTION FORM

Pitot Tube No: 176 Date: 10/7/2011 Inspectors Name: RJG



Pitot tube assembly level? x yes ____ no

Pitot tube openings damaged? ____ yes (explain below) x no

a_1 = 1 ° (<10°), a_2 = 1 ° (<10°) z = A sin g = 0.019 (in.); (<0.125 in.)

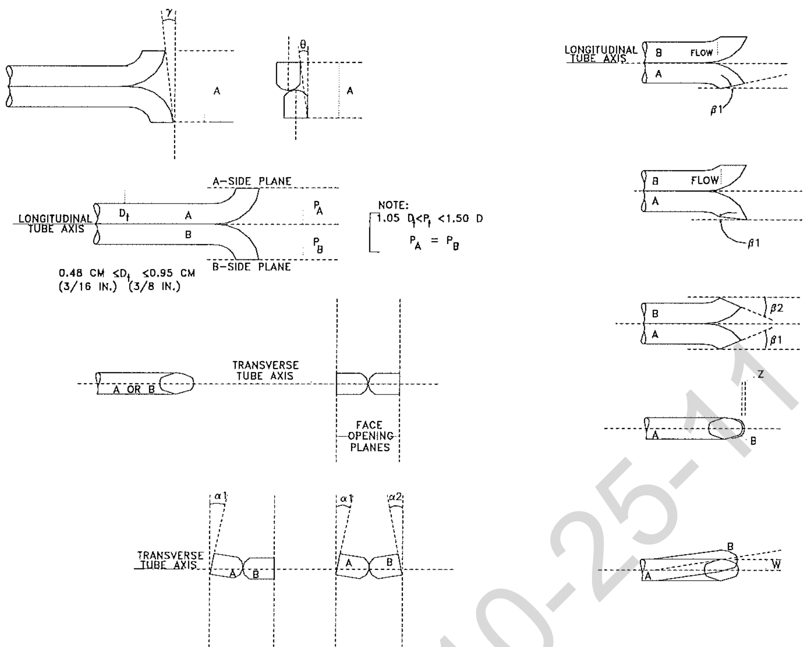
b_1 = 0 ° (<5°), b_2 = 1 ° (<5°) w = A sin q = 0.019 (in.); (<0.03125 in.)

γ = 1 °, θ = 1 °, A = 1.080 (in.) P_A = 0.540 (in.), P_B = 0.540 (in.), D_t = 0.375 (in.)

Calibration required? ____ yes x no

S TYPE PITOT TUBE INSPECTION FORM

Pitot Tube No: 179 Date: 8/4/2011 Inspectors Name: KRA



Pitot tube assembly level? x yes ____ no

Pitot tube openings damaged? ____ yes (explain below) x no

a_1 = 0 ° (<10°), a_2 = 0.5 ° (<10°) z = A sin g = 0.020 (in.); (<0.125 in.)

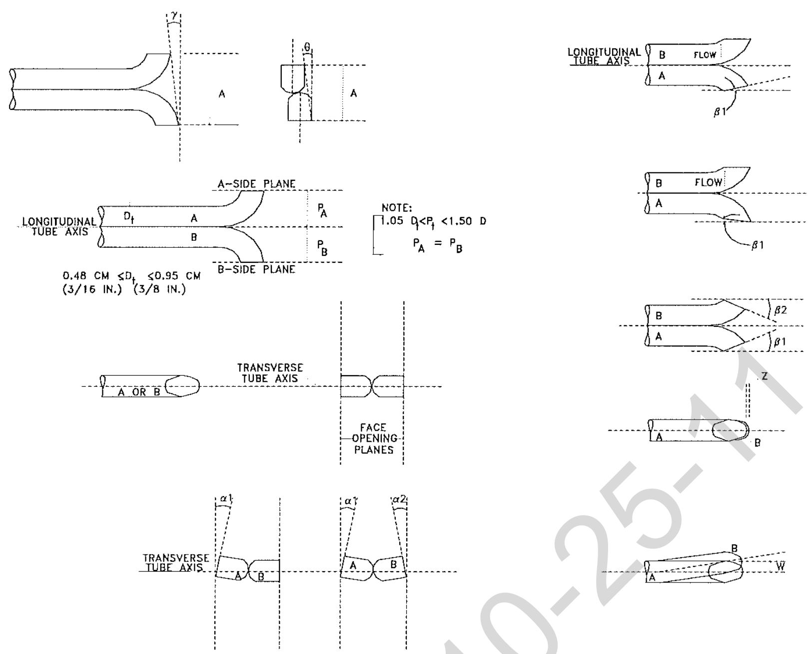
b_1 = 0 ° (<5°), b_2 = 3 ° (<5°) w = A sin q = 0.020 (in.); (<0.03125 in.)

γ = 1 °, θ = 1 °, A = 1.136 (in.) P_A = 0.561 (in.), P_B = 0.561 (in.), D_t = 0.375 (in.)

Calibration required? ____ yes x no

S TYPE PITOT TUBE INSPECTION FORM

Pitot Tube No: 179 Date: 10/7/2011 Inspectors Name: RJG



Pitot tube assembly level? x yes ____ no

Pitot tube openings damaged? ____ yes (explain below) x no

a_1 = 2 ° (<10°), a_2 = 1 ° (<10°) z = A sin g = 0.020 (in.); (<0.125 in.)

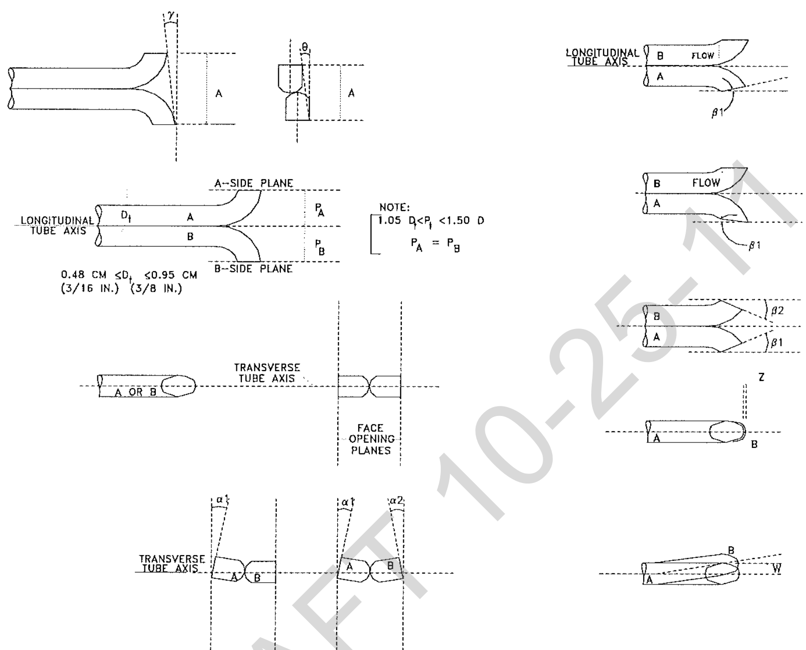
b_1 = 1 ° (<5°), b_2 = 3 ° (<5°) w = A sin q = 0.020 (in.); (<0.03125 in.)

γ = 1 °, θ = 1 °, A = 1.128 (in.) P_A = 0.564 (in.), P_B = 0.564 (in.), D_t = 0.375 (in.)

Calibration required? ____ yes x no

S TYPE PITOT TUBE INSPECTION WORKSHEET

Pitot Tube No: 182 Date: 9/14/2011 Inspectors Name: KRA



Pitot tube assembly level? x yes ______ no

Pitot tube openings damaged? ______ yes (explain below) x no

a_1 = 0.5 ° (<10°), a_2 = 3 ° (<10°) z = A sin g = 0.009 (in.); (<0.125 in.)

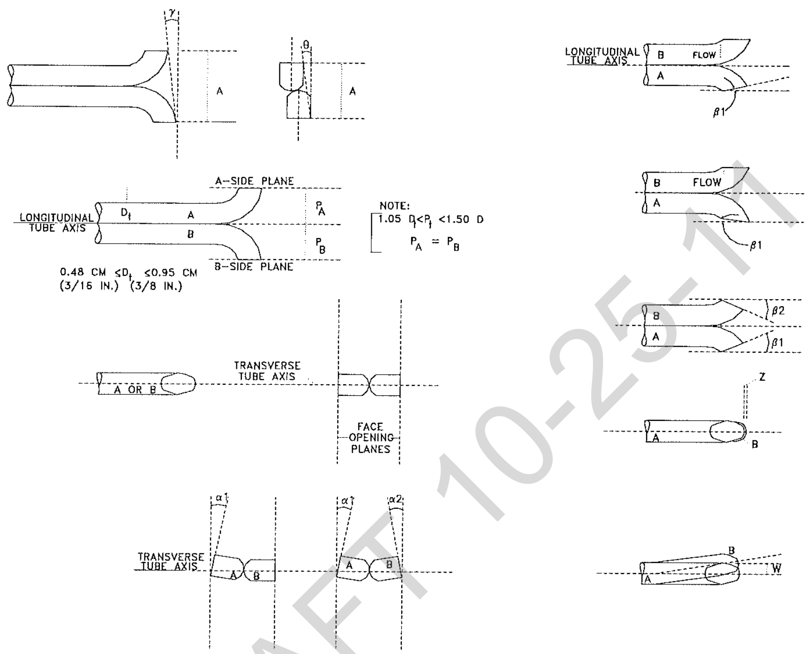
b_1 = 3 ° (<5°), b_2 = 1.5 ° (<5°) w = A sin q = 0.019 (in.); (<0.03125 in.)

γ = 0.5 °, θ = 1 °, A = 1.073 (in.) P_A = 0.536 (in.), P_B = 0.537 (in.), D_t = 0.375 (in.)

Calibration required? ______ yes x no

S TYPE PITOT TUBE INSPECTION WORKSHEET

Pitot Tube No: 182 Date: 10/13/2011 Inspectors Name: SD



Pitot tube assembly level? x yes ____ no

Pitot tube openings damaged? ____ yes (explain below) x no

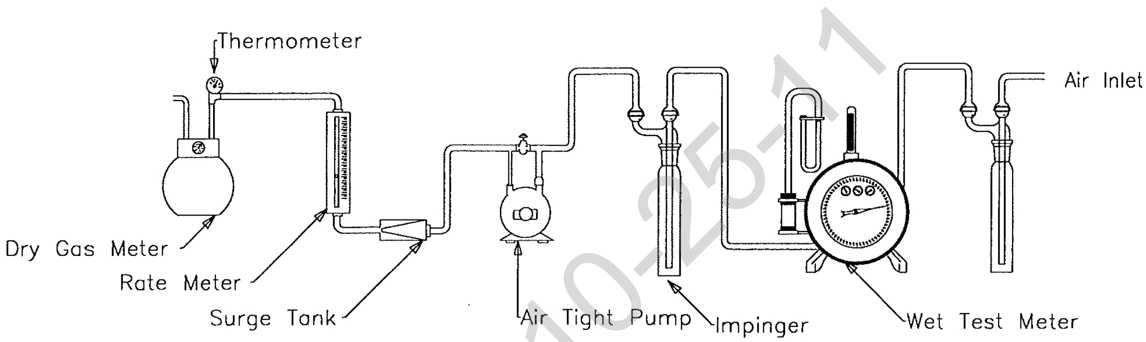
a_1 = 2 ° (<10°), a_2 = 3 ° (<10°) z = A sin g = 0.000 (in.); (<0.125 in.)

b_1 = 3.5 ° (<5°), b_2 = 2 ° (<5°) w = A sin q = 0.019 (in.); (<0.03125 in.)

γ = 0 °, θ = 1 °, A = 1.067 (in.) P_A = 0.534 (in.), P_B = 0.533 (in.), D_t = 0.375 (in.)

Calibration required? ____ yes x no

Dry Gas Meter Calibration Sample Train Diagram



Volumetric Flow Rate Determination Field Data Sheet

Project Number:	M 113908	Date:	09-27-11
Client:	Manitowoc Public Util.	Test Number:	Pre Test Null Pt
Test Location:	Boiler 9 Outlet Duct	Start Time:	1453
Source Condition:	Normal Load	End Time:	1512
Test Engineer:	Al Sorce	Test Tech:	Rod Sellors

Duct Diameter 9.0 ft
Flue Area 63.617 ft^2
Port Length 18.0 "
P_{bar} 29.15 "Hg
Static -1.00 "H_2O
Static ______ "Hg
P_s ______ "Hg

CO_2 % 14.0
O_2 % 5.2
N_2 % 80.8
Meter No. CM-11

Upstream Disturbance, Diameters ______
Downstream Disturbance, Diameters ______
Pitot ID 176-A Pitot Coefficient (C_p) 0.840
Wet Bulb Temp 135
Dry Bulb Temp 330
B_{ws} 0.102

Leak Checks
Pre ✓✓
Post ✓✓

Port-Point #	ΔP	Temp. °F	$\sqrt{\Delta P}$	Null Point Angle, Degrees	Port-Point #	ΔP	Temp. °F	$\sqrt{\Delta P}$	Null Point Angle, Degrees
A-1	0.25	328		0	B-1	0.18	328		0
2	0.26	328		12	2	0.26	328		~~12~~ 10
3	0.26	328		15	3	0.29	329		15
4	0.24	329		18	4	0.19	329		17
5	0.21	329		19	5	0.18	330		0
6	0.23	329		14	6	0.14	330		6
7	0.22	329		9	7	0.13	330		5
8	0.19	328		2	8	0.10	330		2
									142/16
									8.88°
									Pass
Average									

$.44 \times CO_2\% + .32 \times O_2\% + .28 \times N_2\% =$ ______(Md)

(________Md × ________1-Bws) + (18 × _______Bws) = ______(Ms)

$$85.49 \times \_\_\_ Cp \times \sqrt{\frac{(\_\_\_\_\_\_)Ts\ °R}{\_\_\_ Ms \times \_\_\_ Ps}} \times \_\_\_ \sqrt{\Delta P} = \_\_\_ \ ft/sec\ (Vs)$$

______ Vs × ______ Flue Area × 60 = _______________ acfm

$$17.647 \times \_\_\_\_\_ acfm \times \frac{Ps}{Ts\ °R} = \_\_\_\_\_\_\_\_\_\_ scfm \times 60 = \_\_\_\_\_\_\_\_\_\_ scfh$$

Isokinetic Sampling Cover Sheet

Test Engineer: A.L. SORCE
Test Technician: ROD SOLLARS

Plant Information

Run Number: 1
Test Location: Boiler 9 Outlet Duct
Duct Shape: Circular or Rectangular
Flue Area: 63.617 ft^2
Port Type: FLANGE
Test Method: ctm-027

Date: 09-28-11
Client Name: Manitowoc Public Util
Length: ______ Width: ______ or Diameter: 9.0'
Upstream Diameters: ______
Port Length: 15.00"
Source Condition: HIGH LOAD

Project Number: M113908
Plant Name: Manitowoc
Downstream Diameters: ______
Port Diameter: 6.00"

Meter and Probe Data

Meter ID: CM-11
Pitot ID: 179-A
Nozzle Kit ID: TEFLON #5
Probe Length: 10.0'
Pre-Test Nozzle Leak Check: 0.00 @ 10.0 "Hg
Pre-Test Pitot Leak Check: +3/+3 "H_2O

Meter Y Value: 1.015
Pitot Coefficient: 0.840
Nozzle Diameter: 0.305
Probe Liner: GLASS

ΔH Value: 1.579
Train Type: HOT BOX
Filter Number/Weight: HP
Thimble Number/Weight: —
Post-Test Nozzle Leak Check: 0.0 @ 15 "Hg
Post-Test Pitot Leak Check: +3/+3 "H_2O

Traverse Data

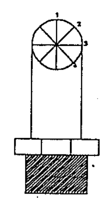
Ports Sampled: 2
Total Points: 24
Points/Port: 12
Total Test Time: 60
Min/Point: 2.5
Sample Plane: Horizontal or Vertical BOTH

Stack Parameters

Barometric Pressure: 29.09
CO_2 %: ___/___/___/ Avg. 14.0
Static Pressure: +0.20
O_2 %: ___/___/___/Avg. 5.3
Determined by: Method 3 or Method 3A
Imp and/or silica balance Model and S/N: ______
Servomex Serial #: ______
Initial Imp. Volume or Weight: 2054.0
Initial Silica Weight: 769.2
Final Imp. Volume or Weight: 2131.0
Final Silica Weight: 817.0
Imp. Volume or Weight Gain: 76.1
Silica Weight Gain: 20.8

Comments:

Post-Test Nozzle Verification:



1)_____ 2)_____ 3)_____ 4)_____

DS-004 Rev042809

Isokinetic Sampling Field Data Sheet

Project Number:	M 113908	Date:	09-28-11	Test Number:	1
Client:	Manitowoc Public Util	Test Location:	Boiler 9 Outlet	Operator:	ALS Test Tech: Rod S
Plant:	Manitowoc	Test Method:	ctm-027 K	Page Number:	1 of 1

Port-Point #	CEMS Time Time	(ΔP)	K_1 4.401 Orifice Setting (ΔH)	Meter Volume (V_m) ft^3, Actual	Square Root, ΔP	1.244 Meter Rate, Cubic Feet/Min.	×2.5 Theoretical Meter Volume, (V_m) ft^3, per point	Theoretical Meter Volume, (V_m) ft^3, total	Stack Temp, °F	Meter Temp Inlet, °F	Meter Temp Outlet, °F	Pump Vacuum, " Hg	Probe Temp. °F	Filter Temp. °F	Impinger Outlet Well Temp °F
A-1	1130	0.82	3.61	14.929	0.906	1.126	2.816		340	63	62	7.0	330	250	57
2	1132.5	0.72	3.17	17.73	0.849	1.056	2.639	17.745	340	64	62	7.0	330	250	56
3	1135	0.63	2.77	20.41	0.794	0.987	2.468	20.384	341	66	62	6.0	330	250	56
4	1137.5	0.40	1.76	22.86	0.632	0.787	1.967	22.852	341	66	62	5.0	330	250	57
5	1140	0.51	2.25	24.84	0.714	0.888	2.221	24.819	341	68	62	5.0	330	250	56
6	1142.5	0.53	2.33	27.09	0.728	0.906	2.264	27.040	341	69	63	5.0	330	250	56
7	1145	0.86	3.79	29.35	0.927	1.154	2.884	29.304	341	70	63	6.0	330	250	54
8	1147.5	0.55	2.42	32.21	0.742	0.923	2.306	32.188	342	71	63	5.0	330	250	56
9	1150	1.00	4.40	34.53	1.000	1.244	3.110	34.494	342	71	64	7.0	330	250	57
10	1152.5	1.00	4.40	37.61	1.000	1.244	3.110	37.604	342	71	64	7.0	330	250	58
11	1155	0.93	4.09	40.69	0.964	1.200	2.999	40.714	342	72	64	8.0	330	250	59
12	1157.5	1.00	4.40	43.63	1.000	1.244	3.110	43.713	342	72	64	8.0	330	250	59
	1200			46.871				46.823							
B-1	1210	0.68	2.99		0.825	1.026	2.565		341	67	65	6.0	330	250	57
2	1212.5	0.68	2.99	49.42	0.825	1.026	2.565	49.388	341	68	65	6.0	330	250	55
3	1215	0.69	3.04	51.98	0.831	1.033	2.583	51.953	341	69	65	6.0	330	250	53
4	1217.5	0.67	2.95	54.59	0.819	1.018	2.546	54.536	341	70	65	6.0	330	250	54
5	1220	0.65	2.86	57.07	0.806	1.003	2.507	57.082	341	71	65	6.0	330	250	54
6	1222.5	0.62	2.73	59.61	0.787	0.980	2.449	59.589	341	72	66	6.0	330	250	54
7	1225	0.70	3.08	62.06	0.837	1.041	2.602	62.038	341	74	66	6.0	330	250	56
8	1227.5	0.84	3.70	64.63	0.917	1.140	2.850	64.640	341	75	66	7.0	330	250	57
9	1230	1.00	4.40	67.47	1.000	1.244	3.110	67.490	342	75	67	8.0	330	250	58
10	1232.5	1.10	4.84	70.60	1.049	1.305	3.262	70.600	342	75	67	9.0	330	250	58
11	1235	1.00	4.40	73.79	1.000	1.244	3.110	73.862	342	75	68	9.0	330	250	59
12	1237.5	0.85	3.75	76.93	0.922	1.147	2.867	76.972	342	76	68	9.0	330	250	60
	1240			79.844				79.839							

PLATT ENVIRONMENTAL SERVICES INC.

IMPINGER WEIGHT SHEET

PLANT: MANITOWOC

UNIT NO: BOILER 9

LOCATION: OUTLET DUCT

DATE: 09-28-11

TEST NO: 1

METHOD: ctm-027

WEIGHED/MEASURED BY: ALS

BALANCE ID: S10-19

CO_2 14.0

O_2 5.3

Circle One:	FINAL WEIGHT MLS / GRAMS	INITIAL WEIGHT MLS / GRAMS	IMPINGER GAIN	IMPINGER CONTENTS
IMPINGER 1	776.3	724.8	51.5	100 ml 0.1N H_2SO_4
IMPINGER 2	751.6	736.6	15.0	100 ml 0.1N H_2SO_4
IMPINGER 3	602.2	592.6	9.6	BLANK
IMPINGER ~~4~~			+(76.1)	
IMPINGER ~~5~~ 4	817.0	796.2	20.8	SILICA
IMPINGER 6				
IMPINGER 7				
IMPINGER 8			96.9	

FINAL TOTAL | INITIAL TOTAL | TOTAL GAIN

Isokinetic Sampling Cover Sheet

Test Engineer: A.L. Sorce
Test Technician: Rod Sollars

Plant Information

Run Number: 2
Test Location: Boiler 9 Outlet Duct
Duct Shape: Circular or Rectangular
Flue Area: 63.617 ft²
Port Type: FLANGE
Test Method: ctm-027

Date: 09-28-11
Client Name: Manitowoc Publ. Util.
Length: — Width: — or Diameter: 9.0'
Upstream Diameters:
Port Length: 15.00"
Source Condition: HIGH LOAD

Project Number: M113908
Plant Name: MANITOWOC
Downstream Diameters:
Port Diameter: 6.00"

Meter and Probe Data

Meter ID: CM-11
Pitot ID: 179-A
Nozzle Kit ID: TEFLON #5
Probe Length: 10.1'
Pre-Test Nozzle Leak Check: 0.002 @ 10.0 "Hg
Pre-Test Pitot Leak Check: +3 / +3 "H_2O

Meter Y Value: 1.015
Pitot Coefficient: 0.840
Nozzle Diameter: 0.305
Probe Liner: GLASS

ΔH Value: 1.579
Train Type: Hot Box
Filter Number/Weight: HP
Thimble Number/Weight: —
Post-Test Nozzle Leak Check: 0.00 @ 15.0 "Hg
Post-Test Pitot Leak Check: +3 / +3 "H_2O

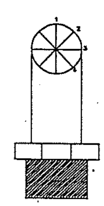
Traverse Data

Ports Sampled: 2
Total Points: 24
Points/Port: 12
Total Test Time: 60
Min/Point: 2.5
Sample Plane: Horizontal or Vertical — BOTH

Stack Parameters

Barometric Pressure: 29.09
Static Pressure: + 0.20" H_2O
CO_2 %: / / / Avg. 13.8
O_2 %: / / /Avg. 5.5
Determined by: Method 3 or Method 3A
Imp and/or silica balance Model and S/N:
Servomex Serial #:
Initial Imp. Volume or Weight: 2041.2
Final Imp. Volume or Weight: 2131.0
Imp. Volume or Weight Gain: 89.8
Initial Silica Weight: 811.7
Final Silica Weight: 828.5
Silica Weight Gain: 16.8

Comments:

Post-Test Nozzle Verification:  1)____ 2)____ 3)____ 4)____

Isokinetic Sampling Field Data Sheet

Project Number: M113908
Client: Manitowoc Publ. Util.
Plant: Manitowoc, WI

Date: 09/28/11
Test Location: Boiler 9 Outlet Duct
Test Method: ctm-027

Test Number: 2
Operator: ALS Test Tech: Roo S.
Page Number: 1 of 1

Port-Point #.	Time	(ΔP)	K_1 4.659 Orifice Setting (ΔH)	Meter Volume (V_m) ft^3, Actual	Square Root, ΔP	K 1.292 Meter Rate, Cubic Feet/ Min.	X 2.5 Theoretical Meter Volume, (V_m) ft^3, per point	Theoretical Meter Volume, (V_m) ft^3, total	Stack Temp, °F	Meter Temp Inlet, °F	Meter Temp Outlet, °F	Pump Vacuum, " Hg	Probe Temp. °F	Filter Temp. °F	Impinger Outlet Well Temp °F
A-1	1345	0.70	3.26	80.220	0.837	1.081	2.702		341	66	65	4.0	320	250	58
2	1347.5	0.71	3.31	82.85	0.843	1.089	2.722	82.922	341	68	65	4.0	320	250	47
3	1350	0.68	3.17	85.66	0.825	1.065	2.664	85.644	341	69	65	4.0	320	250	45
4	1352.5	0.68	3.17	88.30	0.825	1.065	2.664	88.308	341	70	65	4.0	320	250	45
5	1355	0.62	2.89	90.93	0.787	1.017	2.543	90.972	341	72	65	4.0	320	250	46
6	1357.5	0.64	2.98	93.48	0.800	1.034	2.584	93.515	341	73	66	5.0	320	250	47
7	1400	0.70	3.26	96.07	0.837	1.081	2.702	96.099	341	73	66	5.0	320	250	48
8	1402.5	0.80	3.73	98.79	0.894	1.156	2.889	98.801	341	74	66	5.0	320	250	49
9	1405	0.94	4.38	101.66	0.970	1.253	3.132	101.690	342	74	66	6.0	320	250	50
10	1407.5	0.98	4.57	104.85	0.990	1.279	3.198	104.822	342	74	67	6.0	320	250	51
11	1410	1.00	4.66	107.98	1.000	1.292	3.230	108.020	342	74	67	7.0	320	250	54
12	1412.5	1.00	4.66	111.17	1.000	1.292	3.230	111.250	342	74	67	7.0	320	250	55
	1415			114.492				114.480							
B-1	1430	0.75	3.49	114.689	0.866	1.119	2.797		340	68	66	5.0	320	250	57
2	1432.5	0.52	2.42	117.49	0.721	0.932	2.329	117.486	340	69	66	4.0	320	250	53
3	1435	0.58	2.70	119.84	0.762	0.984	2.460	119.815	341	70	66	4.0	320	250	54
4	1437.5	0.50	2.33	122.31	0.707	0.914	2.284	122.275	341	71	66	4.0	320	250	55
5	1440	0.40	1.86	124.58	0.632	0.817	2.043	124.559	341	71	66	4.0	320	250	55
6	1442.5	0.50	2.33	126.67	0.707	0.914	2.284	126.602	341	72	66	4.0	320	250	56
7	1445	0.81	3.77	128.92	0.900	1.163	2.907	128.886	342	72	66	4.0	320	250	56
8	1447.5	0.96	4.47	131.84	0.980	1.266	3.165	131.793	342	73	66	5.0	320	250	57
9	1450	0.88	4.10	134.89	0.936	1.212	3.030	134.958	342	72	66	6.0	320	250	57
10	1452.5	1.00	4.66	138.01	1.000	1.292	3.230	137.988	342	72	66	6.0	320	250	58
11	1455	1.00	4.66	141.25	1.000	1.292	3.230	141.218	342	72	66	5.0	320	250	58
12	1457.5	0.92	4.29	144.46	0.959	1.239	3.098	144.448	341	73	67	5.0	320	250	57
	1500			147.541				147.546							

PLATT ENVIRONMENTAL SERVICES INC.

IMPINGER WEIGHT SHEET

PLANT: MANITOWOC

UNIT NO: BOILER 9

LOCATION: OUTLET DUCT

DATE: 09-28-11

TEST NO: 2

METHOD: ctm-027

WEIGHED/MEASURED BY: ALS

BALANCE ID: S10-19

CO_2 13.8

O_2 5.5

Circle One:	FINAL WEIGHT MLS / GRAMS	INITIAL WEIGHT MLS / GRAMS	IMPINGER GAIN	IMPINGER CONTENTS
IMPINGER 1	760.2	689.2	71.0	100ml 0.1N H_2SO_4
IMPINGER 2	749.4	736.7	12.7	100ml 0.1N H_2SO_4
IMPINGER 3	621.4	615.3	6.1	BLANK
~~IMPINGER 4~~			89.8	
IMPINGER ~~5~~ 4	828.5	811.7	16.8	SILICA
IMPINGER 6				
IMPINGER 7				
IMPINGER 8				

FINAL TOTAL	INITIAL TOTAL	TOTAL GAIN
		106.6

Isokinetic Sampling Cover Sheet

Test Engineer: A. L. SORCE
Test Technician: ROD SOLLARS

Plant Information

Run Number: 3
Test Location: Boiler 9 Outlet Duct
Duct Shape: Circular or Rectangular
Flue Area: 63.617 ft^2
Port Type: FLANGE
Test Method: ctm - 027

Date: 09-28-11
Client Name: Manitowoc Public Util.
Length: — Width: — or Diameter: 9.01
Upstream Diameters:
Port Length: 15.00"
Source Condition: HIGH LOAD

Project Number: M 113908
Plant Name: Manitowoc
Downstream Diameters:
Port Diameter: 6.00"

Meter and Probe Data

Meter ID: CM-11
Pitot ID: 179-A
Nozzle Kit ID TEFLON #5
Probe Length: 10.1 FT
Pre-Test Nozzle Leak Check: 0.00 @ 15.0 "Hg
Pre-Test Pitot Leak Check: +4/+4 "H_2O

Meter Y Value: 1.015
Pitot Coefficient: 0.840
Nozzle Diameter: 0.305
Probe Liner: GLASS

ΔH Value: 1.579
Train Type: HOT BOX
Filter Number/Weight: HP
Thimble Number/Weight: —
Post-Test Nozzle Leak Check: @ "Hg
Post-Test Pitot Leak Check: "H_2O

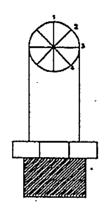
Traverse Data

Ports Sampled: 2
Total Points: 24
Points/Port: 12
Total Test Time: 60
Min/Point: 2.5
Sample Plane: Horizontal or Vertical BOTH

Stack Parameters

Barometric Pressure: 29.09
Static Pressure: + 0.20" H_2O
CO_2 %: / / / Avg. 14.1
O_2 %: / / /Avg. 5.2 Determined by: Method 3 or Method 3A
Imp and/or silica balance Model and S/N:
Servomex Serial #:
Initial Imp. Volume or Weight: 2164.5
Final Imp. Volume or Weight: 2253.5
Imp. Volume or Weight Gain: 89.0
Initial Silica Weight: 796.6
Final Silica Weight: 810.9
Silica Weight Gain: 14.3

Comments:

Post-Test Nozzle Verification:  1)____ 2)____ 3)____ 4)____

DS-004 Rev042809

Isokinetic Sampling Field Data Sheet

Project Number: M113908
Client:
Plant:

Date: 09/28/11
Test Location: Boiler 9 Outlet Duct
Test Method: ctm-027

Test Number: 3
Operator: ALS Test Tech: Rod S
Page Number: 1 of 1

Port-Point #	Time	(ΔP)	K, 4.615 Orifice Setting (ΔH)	Meter Volume (V_m) ft^3, Actual	Square Root, ΔP	1.280 K Meter Rate, Cubic Feet/Min.	× 2.5 Theoretical Meter Volume, (V_m) ft^3, per point	Theoretical Meter Volume, (V_m) ft^3, total	Stack Temp, °F	Meter Temp Inlet, °F	Meter Temp Outlet, °F	Pump Vacuum, " Hg	Probe Temp. °F	Filter Temp. °F	Impinger Outlet Well Temp °F
A-1	1530	0.70	3.23	47.769	0.837	1.071	2.677		341	67	66	3.0	320	250	52
2	1532.5	0.58	2.68	50.42	0.762	0.975	2.437	50.446	341	71	66	3.0	320	250	45
3	1535	0.54	2.49	52.83	0.735	0.941	2.352	52.883	342	72	66	3.0	320	250	46
4	1537.5	0.52	2.40	55.25	0.721	0.923	2.308	55.235	342	73	66	3.0	320	250	46
5	1540	0.52	2.40	57.55	0.721	0.923	2.308	57.543	342	74	67	4.0	320	250	47
6	1542.5	0.54	2.49	59.83	0.735	0.941	2.352	59.851	342	75	67	4.0	320	250	47
7	1545	0.79	3.65	62.21	0.889	1.138	2.844	62.203	342	75	67	4.0	320	250	48
8	1547.5	0.75	3.46	65.04	0.866	1.109	2.771	65.047	343	76	68	5.0	320	250	49
9	1550	1.00	4.62	67.81	1.000	1.280	3.200	67.818	343	76	68	5.0	320	250	49
10	1552.5	1.00	4.62	71.00	1.000	1.280	3.200	71.018	343	77	69	5.0	320	250	50
11	1555	1.10	5.08	74.18	1.049	1.342	3.356	74.218	343	77	69	6.0	320	250	51
12	1557.5	1.00	4.62	77.55	1.000	1.280	3.200	77.574	343	77	69	6.0	320	250	52
	1600			80.782				80.774							
B-1	1605	0.58	2.68		0.762	0.975	2.437		342	74	70	4.0	320	250	51
2	1607.5	0.60	2.77	83.23	0.775	0.991	2.479	83.219	342	75	70	4.0	320	250	48
3	1610	0.60	2.77	85.71	0.775	0.991	2.479	85.698	342	75	70	4.0	320	250	48
4	1612.5	0.64	2.95	88.22	0.800	1.024	2.560	88.177	342	76	70	4.0	320	250	49
5	1615	0.64	2.95	90.78	0.800	1.024	2.560	90.737	342	77	70	4.0	320	250	50
6	1617.5	0.60	2.77	93.33	0.775	0.991	2.479	93.297	342	78	70	4.0	320	250	50
7	1620	0.65	3.00	95.80	0.806	1.032	2.580	95.776	342	78	70	4.0	320	250	51
8	1622.5	0.77	3.55	98.39	0.877	1.123	2.808	98.356	343	78	71	4.0	320	250	52
9	1625	0.92	4.25	101.21	0.959	1.228	3.069	101.164	343	78	71	4.0	320	250	52
10	1627.5	0.98	4.52	104.25	0.990	1.267	3.168	104.233	343	78	71	5.0	320	250	53
11	1630	1.00	4.62	107.42	1.000	1.280	3.200	107.401	343	79	71	5.0	320	250	54
12	1632.5	1.10	5.08	110.58	1.049	1.342	3.356	110.601	343	79	71	5.0	320	250	54
	1635			113.973				113.957							

PLATT ENVIRONMENTAL SERVICES INC.

IMPINGER WEIGHT SHEET

PLANT: Manitowoc Public Util.

UNIT NO: Boiler 9

LOCATION: Outlet Duct

DATE: 9/28/11

TEST NO: 3

METHOD: ctm-027

WEIGHED/MEASURED BY: ALS

BALANCE ID: S10-19

CO_2 14.1
O_2 5.2

Circle One:	FINAL WEIGHT MLS / GRAMS	INITIAL WEIGHT MLS / GRAMS	IMPINGER GAIN	IMPINGER CONTENTS
IMPINGER 1	796.8	728.3	68.5	100ml 0.1N H_2SO_4
IMPINGER 2	755.9	740.0	15.9	100ml 0.1N H_2SO_4
IMPINGER 3	700.8	696.2	4.6	Blank
IMPINGER 4			89.0	
IMPINGER 5	810.9	796.6	14.3	Silica
IMPINGER 6				
IMPINGER 7				
IMPINGER 8				

FINAL TOTAL	INITIAL TOTAL	TOTAL GAIN
		103.3

DS-005A Impinger Weight Sheet

Platt Environmental Services, Inc.

H_2SO_4 VAPOR FIELD DATA SHEET
Controlled Condensate (CCS)
(NCASI Method 8A)

Project Number: M 113908   Date: 09/29/11

Project: MANITOWOC PUBLIC UTILITIES   Test #: 1

Sampling Location: BOILER 9 Outlet DUCT CO_2 = 14.0

Source Condition: HIGH LOAD O_2 = 5.2

Dry Gas Meter No. CM-11   Y = 1.015   Δ H = 1.579

Barometric Pressure: 29.05 in. Hg   Moisture Gain: 0.070

Leak Check: Pre-sampling 0.00 cfm @ 8.0 in. Hg vacuum
Post-sampling 0.00 cfm @ 8.0 in. Hg vacuum

Clock Time (24 hrs.)	Meter Volume (V_m) ft^3	Orifice Gauge Pressure (ΔH) in. H_2O	Temperature							
			Stack (°F)	≥ 500° Probe (°F)	Filter ≥ 500° Probe (°F)	≈140° Condenser Water (°F)	Coil Exit (°F)	Dry Gas Meter Inlet (°F)	Dry Gas Meter Outlet (°F)	Impinger Outlet (°F)
0840	6.690	0.03	340	550	500	141	60	64	63	63
0845	7.209	0.03	340	550	500	141	90	65	63	62
0850	7.713	0.03	340	550	500	140	90	65	63	62
0855	8.221	0.03	340	550	500	141	91	66	64	62
0900	8.732	0.03	340	550	500	141	95	66	65	62
0905	9.250	0.03	340	550	500	140	94	67	65	62
0910	9.764	0.03	340	550	500	140	94	67	65	62
0915	10.276	0.03	340	550	500	140	95	68	66	63
0920	10.785	0.03	340	550	500	140	93	68	66	63
0925	11.297	0.03	340	550	500	140	93	69	67	63
0930	12,809	0.03	340	550	500	140	93	69	67	63
0935	13.312	0.03	340	550	500	140	93	70	68	63
0940	13.834									
Avg.									66.08	62.5

Operator: A. L. SORGE

DS-010 (rev. 2/25/10)

Volumetric Flow Rate Determination Field Data Sheet

Project Number: M 113908
Date: 09-29-11
Client: Manitowoc Public Utilities
Test Number: Pre Flow
Test Location: Boiler 9 Outlet Duct
Start Time: 0821
Source Condition: High Load
End Time: 0834
Test Engineer: A. L. Sorce
Test Tech: Rod. S

Duct Diameter 9.0 ft
Flue Area 63.617 ft^2
Port Length 11.0 "
P_{bar} 29.05 "Hg
Static +0.20 "H_2O
Static +0.01 "Hg
P_s 29.06 "Hg

CO_2 % 14.0
O_2 % 5.2
N_2 % 80.8
Meter No. CM-11

Upstream Disturbance, Diameters ______
Downstream Disturbance, Diameters ______
Pitot ID 182-B Pitot Coefficient (C_p) 0.840
Wet Bulb Temp ——
Dry Bulb Temp ——
B_{ws} 0.081

Leak Checks
Pre +3/+3
Post +3/+3

Port-Point #	ΔP	Temp. °F	$\sqrt{\Delta P}$	Null Point Angle, Degrees	Port-Point #	ΔP	Temp. °F	$\sqrt{\Delta P}$	Null Point Angle, Degrees
A-1	0.54	330			B-1	0.18	338		
2	0.58	333			2	0.64	338		
3	0.60	337			3	0.72	339		
4	0.61	338			4	0.69	339		
5	0.62	339			5	0.68	339		
6	0.61	340			6	0.64	340		
7	0.81	340			7	0.63	340		
8	0.62	340			8	0.76	340		
9	0.83	340			9	0.81	340		
10	0.89	340			10	0.90	340		
11	0.84	338			11	0.98	340		
12	0.83	337			12	0.98	340		
Average									

$.44 \times CO_2\% + .32 \times O_2\% + .28 \times N_2\% =$ ______(Md)

(________Md × ________1-Bws) + (18 × _______Bws) = ______(Ms)

$85.49 \times \_\_\_ Cp \times \sqrt{\frac{(\_\_\_\_\_\_)Ts\ °R}{\_\_\_\_ Ms \times \_\_\_\_ Ps}} \times \_\_\_\_ \sqrt{\Delta P} = \_\_\_\_$ ft/sec (Vs)

______ Vs × ______ Flue Area × 60 = _______________ acfm

$17.647 \times \_\_\_\_\_\_ acfm \times \frac{Ps}{Ts\ °R} = \_\_\_\_\_\_\_\_\_\_\_$ scfm x 60 = ___________ scfh

Volumetric Flow Rate Determination Field Data Sheet

Project Number: M 113908
Client: Manitowoc Public Utilities
Test Location: Boiler 9 Outlet Duct
Source Condition: HIGH LOAD
Test Engineer: A.L. SORGE

Date: 09-29-11
Test Number: Post 1 / Pre 2
Start Time: 0953
End Time: 1003
Test Tech: ROD SOLLARS

Duct Diameter 9.0 ft
Flue Area 63.617 ft^2
Port Length 11.0 "
P_{bar} 29.05 "Hg
Static +0.20 "H_2O
Static +0.01 "Hg
P_s 29.06 "Hg

CO_2 % 13.85
O_2 % 5.35
N_2 % 80.80
Meter No. CM-11

Upstream Disturbance, Diameters ____
Downstream Disturbance, Diameters ____
Pitot ID 182-B Pitot Coefficient (C_p) 0.840
Wet Bulb Temp ✓
Dry Bulb Temp ✓
B_{ws} 0.081

Leak Checks
Pre +4/+4
Post +3/+3

Port-Point #	ΔP	Temp. °F	$\sqrt{\Delta P}$	Null Point Angle, Degrees	Port-Point #	ΔP	Temp. °F	$\sqrt{\Delta P}$	Null Point Angle, Degrees
A-1	0.56	341			B-1	0.57	341		
2	0.60	341			2	0.56	341		
3	0.63	341			3	0.50	341		
4	0.60	341			4	0.48	341		
5	0.57	341			5	0.47	341		
6	0.55	341			6	0.50	341		
7	0.56	341			7	0.77	342		
8	0.63	341			8	0.88	342		
9	0.68	341			9	1.00	342		
10	0.84	341			10	1.10	342		
11	0.89	341			11	1.00	342		
12	0.83	340			12	1.00	342		
Average									

.44 x CO_2% + .32 x O_2% + .28 x N_2% = ______(Md)

(________Md × ________1-Bws) + (18 ×_______Bws) = ______(Ms)

$85.49 \times$ ___Cp $\times \sqrt{\dfrac{(\_\_\_\_\_\_)Ts\ {}^\circ R}{\_\_\_Ms \times \_\_\_Ps}} \times$ ___ $\sqrt{\Delta P}$ = ___ ft/sec (Vs)

______ Vs × ______ Flue Area × 60 = _______________acfm

17.647 × _____acfm × $\dfrac{Ps}{Ts\ {}^\circ R}$ = __________ scfm x 60 = __________ scfh

Volumetric Flow Rate Determination Field Data Sheet

Project Number: M 113908
Date: 09-29-11
Client: Manitowoc Public Utilities
Test Number: Post 2 / Pre 3
Test Location: Boiler 9 Outlet Duct
Start Time: 1145
Source Condition: High Load
End Time: 1156
Test Engineer: A. L. Sorce
Test Tech: Rod. Sollars

Duct Diameter 9.0 ft
Flue Area 63.617 ft²
Port Length 11.0 "
P_{bar} 29.05 "Hg
Static +0.20 "H_2O
Static +0.01 "Hg
P_s 29.06 "Hg

Upstream Disturbance, Diameters ______
Downstream Disturbance, Diameters ______
Pitot ID 182-B Pitot Coefficient (C_p) 0.840

CO_2 % 13.95
O_2 % 5.25
N_2 % 80.80
Meter No. CM-11

Wet Bulb Temp —
Dry Bulb Temp —
B_{ws} 0.78

Leak Checks
Pre +4/+4
Post +4/+4

Port-Point #	ΔP	Temp. °F	$\sqrt{\Delta P}$	Null Point Angle, Degrees	Port-Point #	ΔP	Temp. °F	$\sqrt{\Delta P}$	Null Point Angle, Degrees
A-1	0.72	342			B-1	0.55	341		
2	0.65	344			2	0.63	341		
3	0.57	344			3	0.64	341		
4	0.50	344			4	0.60	341		
5	0.52	344			5	0.57	341		
6	0.54	344			6	0.56	341		
7	0.68	344			7	0.58	342		
8	0.81	344			8	0.61	343		
9	0.90	344			9	0.63	343		
10	0.98	344			10	0.68	343		
11	1.20	344			11	0.71	343		
12	1.10	343			12	0.74	343		
Average									

$.44 \times CO_2\% + .32 \times O_2\% + .28 \times N_2\% =$ ______(Md)

(________Md × ________1-Bws) + (18 × _______Bws) = ______(Ms)

$$85.49 \times \_\_\_ C_p \times \sqrt{\frac{(\_\_\_\_\_\_)T_s\ {}^\circ R}{\_\_\_ M_s \times \_\_\_ P_s}} \times \_\_\_\ \sqrt{\Delta P} = \_\_\_\ \text{ft/sec}\ (V_s)$$

______ Vs × ______ Flue Area × 60 = _______________acfm

$$17.647 \times \_\_\_\_\_\ \text{acfm} \times \frac{P_s}{T_s\ {}^\circ R} = \_\_\_\_\_\_\_\_\_\ \text{scfm} \times 60 = \_\_\_\_\_\_\_\_\_\ \text{scfh}$$

Volumetric Flow Rate Determination Field Data Sheet

Project Number: M113908 Date: 09-29-11
Client: Manitowoc Public Utilities Test Number: Post 3
Test Location: Boiler 9 Outlet Duct Start Time: 1343
Source Condition: High Load End Time: 1354
Test Engineer: A. L. Sorce Test Tech: Rod Sellars

Duct Diameter 9.0 ft
Flue Area 63.617 ft^2
Port Length 11.0 "
P_{bar} 29.05 "Hg
Static +0.20 "H_2O
Static +0.01 "Hg
P_s 29.06 "Hg

Upstream Disturbance, Diameters ____
Downstream Disturbance, Diameters ____
Pitot ID 182-B Pitot Coefficient (C_p) 0.840
CO_2 % 14.2
O_2 % 5.0
N_2 % 80.8
Meter No. CM-11
Wet Bulb Temp —
Dry Bulb Temp —
B_{ws} 0.099
Leak Checks
Pre 44/44
Post 44/44

Port-Point #	ΔP	Temp. °F	$\sqrt{\Delta P}$	Null Point Angle, Degrees	Port-Point #	ΔP	Temp. °F	$\sqrt{\Delta P}$	Null Point Angle, Degrees
A-1	0.55	342			B-1	0.46	344		
2	0.59	342			2	0.53	344		
3	0.66	342			3	0.52	344		
4	0.64	342			4	0.53	344		
5	0.60	342			5	0.55	344		
6	0.61	342			6	0.63	344		
7	0.59	343			7	0.79	344		
8	0.58	343			8	0.89	344		
9	0.66	344			9	0.92	344		
10	0.79	344			10	0.76	344		
11	0.95	344			11	1.00	344		
12	1.00	343			12	1.00	344		
Average									

$.44 \times CO_2\% + .32 \times O_2\% + .28 \times N_2\% =$ ______(Md)

(________Md × ________1-Bws) + (18 × _______Bws) = ______(Ms)

$85.49 \times$ ___Cp $\times \sqrt{\dfrac{(\_\_\_\_\_)Ts\ °R}{\_\_\_Ms \times \_\_\_Ps}} \times$ ___ $\sqrt{\Delta P} =$ ___ ft/sec (Vs)

______ Vs × ______ Flue Area × 60 = _______________acfm

$17.647 \times$ _____acfm $\times \dfrac{Ps}{Ts\ °R} =$ ___________ scfm × 60 = ___________ scfh

MOISTURE FIELD DATA SHEET

Project Name/Number: Manitowoc Public Utilities M113908 Date: 09-29-11
Sampling Location: Boiler 9 Outlet Duct
Source Condition: HIGH LOAD
Dry Gas Meter No. CM-11 Y = 1.015 Test Engineer: A.L. Sorce

Test (Run) No. 1 Barometric Pressure (P_{bar}) 29.05 in. Hg — Gas Temperature 340 °F Static Pressure +0.01 in. Hg — 14.0 %CO_2 Orsat Analysis 5.2 %O_2

Clock Time 24 hour	Meter Volume (V_m) ft³ or L (Circle One)	Meter Gage Pressure (ΔH) in. H_2O	Meter Temp. (t_m) °F	Impgr. Outlet Temp °F
0840	6.690	0.03	66.08	62.5
0940	13.834			
Total Vol.	7.144	[redacted]	[redacted]	[redacted]
Average	[redacted]		(T_m)	°R

Condensate
210 mls (V_f)
- 200 mls (V_i)
10 mls
× 0.04707 = ____
____ ft³ [$V_{wc(std)}$] + ____

Silica Gel or Train
225.2 grams (W_f)
- 221.9 grams (W_i)
3.3 grams
× 0.04715 = ____
ft³ [$V_{wsg(std)}$]
= ____ ft³ [$V_{w(std)}$]

$V_{m(std)}$ = ____ ft³
Water Vapor, proportion by volume
B_{ws} = 0.081

Leak Check:
0.0 @ 8.0" Hg
0.0 @ 8.0" Hg

Moisture correction factor:
1 - B_{ws} = ____

Comments: ΔH = 1.579

Test (Run) No. 2 Barometric Pressure (P_{bar}) 29.05 in. Hg — Gas Temperature 342 °F Static Pressure +0.01 in. Hg — 13.7 %CO_2 Orsat Analysis 5.5 %O_2

Clock Time 24 hour	Meter Volume (V_m) ft³ or L (Circle One)	Meter Gage Pressure (ΔH) in. H_2O	Meter Temp. (t_m) °F	Impgr. Outlet Temp °F
1040	4.308	0.03	71.4	62.5
1140	10.351			
Total Vol.	6.043	[redacted]	[redacted]	[redacted]
Average	[redacted]		(T_m)	°R

Condensate
208 mls (V_f)
- 200 mls (V_i)
8 mls
× 0.04707 = ____
____ ft³ [$V_{wc(std)}$] + ____

Silica Gel or Train
226.6 grams (W_f)
- 224.0 grams (W_i)
2.6 grams
× 0.04715 = ____
ft³ [$V_{wsg(std)}$]
= ____ ft³ [$V_{w(std)}$]

$V_{m(std)}$ = ____ ft³
Water Vapor, proportion by volume
B_{ws} = 0.078

Leak Check:
0.0 @ 8.0" Hg
0.0 @ 8.0" Hg

Moisture correction factor:
1 - B_{ws} = ____

Comments:

$$V_{m(std)} = 17.64\, V_m Y \frac{P_{bar} + \frac{DH}{13.6}}{T_m} \qquad B_{ws} = \frac{V_{w(std)}}{V_{w(std)} + V_{m(std)}}$$

DRAFT 10-25-11

MOISTURE FIELD DATA SHEET

Project Name/Number: M113908 Manitowoc Public Utilities Date: 09-29-11
Sampling Location: Boiler 9 Outlet Duct
Source Condition: HIGH LOAD
Dry Gas Meter No. CM-11 Y = 1.015 Test Engineer: A.L. Sorce

Test (Run) No. 3 Barometric Pressure (P_{bar}) 29.05 in. Hg | Orsat Analysis 14.2 %CO_2 5.0 %O_2
Gas Temperature 343 °F Static Pressure +0.01 in. Hg

Clock Time 24 hour	Meter Volume (V_m) ft³ or L (Circle One)	Meter Gage Pressure (ΔH) in. H_2O	Meter Temp. (t_m) °F	Impgr. Outlet Temp °F
1225	1.331	0.03	70.0	62.8
1325	7.399			
Total Vol.	6.068			
Average			(T_m)	°R

Condensate

208 mls (V_f)
- 200 mls (V_i)
8 mls
× 0.04707 = ________
________ ft³ [$V_{wc(std)}$] + ________

Silica Gel or Train

211.3 grams (W_f)
- 208.5 grams (W_i)
2.8 grams
× 0.04715 = ________
ft³ [$V_{wsg(std)}$]
= ________ ft³ [$V_{w(std)}$]

$V_{m(std)}$ = ________ ft³

Water Vapor, proportion by volume

Leak Check: 0.00 @ 8.0" Hg; 0.00 @ 8.0" Hg

B_{ws} = 0.79

Moisture correction factor:
1 - B_{ws} = ________

Comments:

Test (Run) No. ________ Barometric Pressure (P_{bar}) ________ in. Hg | Orsat Analysis ________ %CO_2 ________ %O_2
Gas Temperature ________ °F Static Pressure ________ in. Hg

Clock Time 24 hour	Meter Volume (V_m) ft³ or L (Circle One)	Meter Gage Pressure (ΔH) in. H_2O	Meter Temp. (t_m) °F	Impgr. Outlet Temp °F
Total Vol.				
Average			(T_m)	°R

Condensate

________ mls (V_f)
- ________ mls (V_i)
________ mls
× 0.04707 = ________
________ ft³ [$V_{wc(std)}$] + ________

Silica Gel or Train

________ grams (W_f)
- ________ grams (W_i)
________ grams
× 0.04715 = ________
ft³ [$V_{wsg(std)}$]
= ________ ft³ [$V_{w(std)}$]

$V_{m(std)}$ = ________ ft³

Water Vapor, proportion by volume

Leak Check:

B_{ws} = ________

Moisture correction factor:
1 - B_{ws} = ________

Comments:

$$V_{m(std)} = 17.64\, V_m Y \frac{P_{bar} + \frac{DH}{13.6}}{T_m}$$

$$B_{ws} = \frac{V_{w(std)}}{V_{w(std)} + V_{m(std)}}$$